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Spring in the Morris Arboretum — What to See and When to See It

H. L. Li

Fig. 1. *Corylopsis spicata* in full bloom.

Spring is the time of flowers and the Morris Arboretum is especially endowed throughout the season with beautiful exhibitions of many kinds of flowering trees and shrubs, native as well as introduced, that are hardy in this climate. The following account briefly outlines the more outstanding floral displays to be anticipated during the spring months of March, April, and May. It lists the blooming dates of a number of common species and those of some rarer but interesting ornamental species (shade trees excluded) to enable visitors to the Arboretum to seek out the plants they would like to see at the time of their flowering. The dates are based on actual records made by the Arboretum staff in the past ten years. Most of the dates are based on multiple observations covering all or nearly all ten years but in some cases the blooming date listed may be based on only a few or even a single record. In times of seasonally abnormal climatic changes a departure of one or two weeks, earlier or later, from the dates given here is to be expected.

March

Spring is ushered in around early March by a profusion of flowering bulbs such as snowdrops and snowflakes all over the lawns. In milder winters these may appear in February or even in January. Appearing slightly later are squills, crocuses, narcissus, daffodils and other bulb plants. Among the earliest flower-

Fig. 2. Narcissus and the Swan Pond at the Morris Arboretum. Spring 1969.

ing woody plants are the witch-hazels (*Hamamelis*), jasmine, Cornelian Cherry (*Cornus mas*) and *Lonicera fragrantissima*. Truly a winter-flowering shrub, the Wintersweet (*Chimonanthus praecox*), with its delicate waxy yellow and exquisitely fragrant flowers sometimes delays its blooming on account of extreme low temperatures, and if the flower buds are not killed, they may open in early March. Specimens of witch-hazels are scattered at various locations throughout the grounds. A cluster of them is planted across the walk from the rock grotto. The other early bloomers are around the south slope of Gates Hall where a collection of spring flowering shrubs and trees is assembled. Later in the month the highly floriferous and widely planted forsythias, Star Magnolias, and Soulange Magnolias burst into profusion to announce that spring has definitely arrived at this part of the world.

Early March

Chimonanthus praecox	1/5 - 4/9
Cornus mas	3/12 - 4/8
Cornus officinalis	3/5 - 4/10
Hamamelis intermedia	3/1 - 3/24
Hamamelis japonica	3/4 - 3/27
Hamamelis mollis	1/28 - 3/20
Hamamelis vernalis	2/8 - 3/5
Jasminum nudiflorum	3/5 - 3/27
Lonicera fragrantissima	1/26 - 3/26
Lonicera purpusii	1/5 - 4/9

Late March

Forsythia ovata	3/27 - 4/15
Forsythia suspensa	3/30 - 4/23
Forsythia viridissima	3/30 - 4/7
Magnolia soulangiana	3/29 - 4/24
Magnolia stellata	3/28 - 4/15
Pieris japonica	3/10 - 4/3
Prunus mume	3/22 - 4/15

April

In April more species are in flower and all over the Arboretum one can find plants in bloom. Species of *Corylopsis* with their delicate yellow flowers in tassels can be found along the walk inside the Germantown Avenue boundary. The first species of Rhododendron in flower can be found in the Rhododendron beds along the fence there. Later in the month more species of Rhododendron follow these pioneers in blossoming. Additional species of Magnolias also come into flower and these are especially visible along the lower slope of the drive from the Service Gate on Meadowbrook Avenue above the meadow. Other notable plants in bloom at this time include the American silverbells (*Halesia* spp.) and the Japanese flowering cherries (*Prunus subhirtella, P. yedoensis*). Toward the later part of the month, the Flowering Dogwood comes into prominence and its flowering display continues well into May.

Early April

Abeliophyllum distichum	4/2 - 4/8
Corylopsis sinensis	4/2 - 4/15
Corylopsis spicata	3/22 - 4/19
Corylopsis veitchiana	4/2 - 4/15
Daphne mezereum	3/21 - 4/1
Daphne odora	3/18 - 4/16
Magnolia kobus	4/1 - 4/15
Magnolia salicifolia	4/1 - 4/16
Rhododendron dauricum	4/1 - 4/13
Rhododendron mucronulatum	4/1 - 4/15

Late April

Amelanchier arborea	4/15 - 4/27
Cercis canadensis	4/15 - 5/8
Cercis chinensis	4/30
Chaenomeles lagenaria	4/10 - 4/30
Chaenomeles sinensis	4/14 - 5/11
Cornus florida	4/24 - 5/10
Elaeagnus multiflora	4/22 - 4/28
Enkianthus perulatus	4/15 - 5/5
Halesia diptera	4/28 - 5/22
Halesia monticola	4/15 - 4/30
Kerria japonica	4/20 - 5/1
Magnolia denudata	4/15 - 4/23
Magnolia loebneri	4/4 - 4/15
Malus spp.	4/27 - 5/16

Pieris floribunda	4/1 - 4/23
Prunus persica	4/21
Prunus subhirtella	4/8 - 4/30
Prunus yedoensis	4/15 - 5/1
Rhododendron canadense	4/29 - 5/15
Rhododendron keiskei	4/18 - 4/28
Rhododendron schlippenbachii	4/22 - 5/9
Ribes odoratum	4/16 - 5/12
Spiraea prunifolia	4/10 - 4/24
Spiraea vulgaris	4/21 - 5/11
Viburnum carlesii	4/21 - 4/27
Viburnum bitchiuense	4/29 - 5/14

May

May is the month when the floral world is at its zenith. By this time so many species are in bloom that it is up to the viewer to especially seek out those plants of particular interest to him. As there are now more different kinds to be seen, this list for the month is divided into three successive periods of blooming. Early in the month wisterias and lilacs are especially notable. Numerous Horse-Chestnuts and Buckeyes (*Aesculus* spp.), azaleas, and viburnums come into flower. During the next part of the month, fringe-trees, deutzias, and styrax bloom. The Mountain Laurel (*Kalmia latifolia*), the State Flower of Pennsylvania, begins to flower, as does the stately Tulip Poplar (*Liriodendron*), the giant of the Pennsylvania forests. The middle part of the month is the time to view the show of hybrid azaleas. The azalea meadow, visible from Hillcrest Avenue to the right of the Entrance Gate, is lined with beds of various hybrids, including many kinds that originated here at the Arboretum. The peak season is usually about May 10–20.

Early May

Crataegus spp.	4/28 - 5/10
Daphne burkwoodii	5/3 - 5/13
Daphne genkwa	5/13
Exochorda racemosa	4/28 - 5/5
Halesia monticola rosea	4/19 - 5/8
Magnolia liliflora	4/23 - 5/7
Neviusia alabamensis	5/1 - 5/18
Paulownia tomentosa	5/7 - 5/9
Rhodotypos scandens	4/30 - 5/3
Spiraea vanhouttei	5/5 - 5/13
Syringa meyeri	5/7
Wisteria floribunda	4/28 - 5/12
Wisteria sinensis	4/18 - 5/3
Xanthoceras sorbifolia	5/1 - 5/10

Fig. 3. *Magnolia stellata*, the Star Magnolia, in bloom on the northwest slope at the Morris Arboretum.

Mid-May

Aesculus carnea	5/14 - 5/23
Aesculus glabra	4/27 - 5/11
Aesculus hippocastanum	5/12 - 5/13
Aesculus octandra	5/5 - 5/18
Calycanthus fertilis	5/13
Enkianthus campanulatus	5/10 - 5/23
Jasminum fruticans	5/14 - 5/20
Kolkwitzia amabilis	5/10 - 5/30
Leucothoe racemosa	5/15 - 5/30
Lyonia ligustrina	5/14
Magnolia acuminata	5/4 - 5/16
Magnolia cordata	5/16
Neillia sinensis	5/13 - 5/18
Robinia pseudoacacia	5/17 - 5/25
Rhododendron atlanticum	5/21
Rhododendron austrinum	5/13 - 5/21
Rhododendron calendulaceum	5/21
Rhododendron canescens	5/15 - 5/17
Rhododendron multiflorum	5/21
Rhododendron speciosum	5/22
Rhododendron viscosum	5/7 - 5/22
Viburnum plicatum	5/7 - 5/22
Viburnum prunifolium	5/6 - 5/14
Viburnum rhytidophyllum	5/1 - 5/13

Viburnum sieboldii	5/9 - 5/29	*Fontanesia fortunei*	5/24
Viburnum tomentosum	5/12 - 5/22	*Hydrangea petiolaris*	5/30
Weigela floribunda	5/12 - 5/29	*Kalmia latifolia*	5/26 - 5/31
		Liriodendron tulipifera	5/20 - 6/1
		Magnolia sieboldii	5/20 - 5/28
Late May		*Magnolia virginiana*	5/25
Buddleia alternifolia	5/28 - 5/31	*Philadelphus* spp.	5/26
Chionanthus retusus	5/10 - 5/23	*Physocarpus opulifolia*	5/31
Chionanthus virginicus	5/12 - 5/29	*Pterostyrax hispida*	5/30 - 6/4
Cladrastis lutea	5/23 - 5/28	*Rosa rugosa*	5/15 - 5/26
Davidia involucrata	5/5 - 5/21	*Styrax japonica*	5/26 - 6/6
Deutzia gracilis	5/22 - 5/31	*Styrax obassia*	5/13 - 5/26
Deutzia scabra	5/31	*Syringa pekinensis*	5/31 - 6/9

About Our Authors

H. L. Li, Ph.D., Harvard, has been a member of the Arboretum staff for many years. During much of that time he resided within the Arboretum boundaries and so became intimately acquainted with the blooming periods of the plants.

Rolla Tryon, Ph.D., Harvard, who was chosen as the Laura L. Barnes Lecturer for 1970, is Curator of Ferns at the Gray Herbarium of Harvard University. Even as the manuscript was in preparation, he journeyed again to Latin America, accompanied by two graduate students of Botany.

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HONORING DR. LAURA L. BARNES WHICH WAS PRESENTED ON NOVEMBER 12, 1970

Ferns of the Andes and Amazon

Rolla Tryon

Introduction

South America has the longest mountain system and the largest river system in the world. These are dominant features which account for the rich plant and animal life of the continent and have been decisive in the evolutionary development of its diverse floras and faunas. The Amazon Basin has been a primary center for speciation of low-land tropical life. The Andes have been a center of evolution for montane, alpine, and desert species and also have been an important route of migration around the Amazon Basin for biota not adapted to the warm, moist tropics.

The ferns are one of the highly diversified groups of plants in South America, in the number of species (about 3000), in their abundance in moist habitats, and in their adaptations to a wide variety of environments. They are a group that represents characteristic aspects of the Andean and Amazonian floras and some features of their past history. The ferns of the Andes and Amazon will be surveyed here across a "transect" from the Pacific coast of Peru, up the western valleys to the high Andes, through the altiplano to the montane forests of the eastern flanks of the Andes and down to the Amazon River. Peru is strategically situated to portray the plant life because it combines some of the principal floristic features of Andean countries to the north and south, and because its long eastward arm along the Amazon River extends well into the heart of the typical Amazonian flora. The map and physiographic profile in Figure 1 show the distribution of the principal fern floras in Peru.

Andean and Amazonian Ferns

The Pacific coast of Peru is a desert and one of the driest places in the world. The remarkable preservation of artifacts, especially the beautiful textiles of the southern Paracas (400 B.C. to 400 A.D.) and the northern Mochicas (400 to 800 A.D.) cultures, bear witness to the continued dryness over the centuries. Moisture does occur regularly during the winter months of July to September at certain topographically favorable sites along the coast. These are called lomas and they receive a total of some 8 to 10 inches

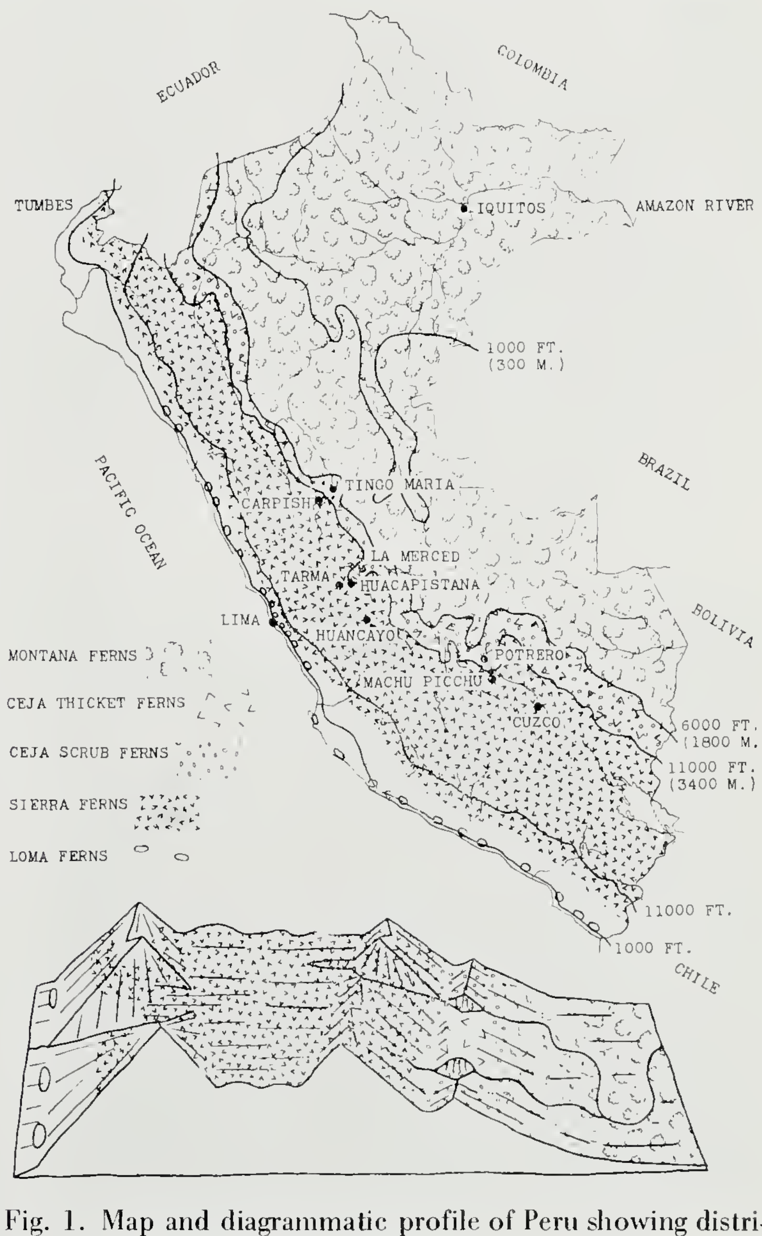


Fig. 1. Map and diagrammatic profile of Peru showing distribution of the principal fern floras.

Fig. 2. *Saffordia induta*, collected in the Department of La Libertad, Peru, by A. Sagástegui in 1958. The densely sealy under surfaee of the leaf (right) and the green, barren, upper surfaee (left).

Fig. 3. *Cheilanthes scariosa* on limestone roeks above Tarma, 11,000 feet. Photograph by A. F. Tryon.

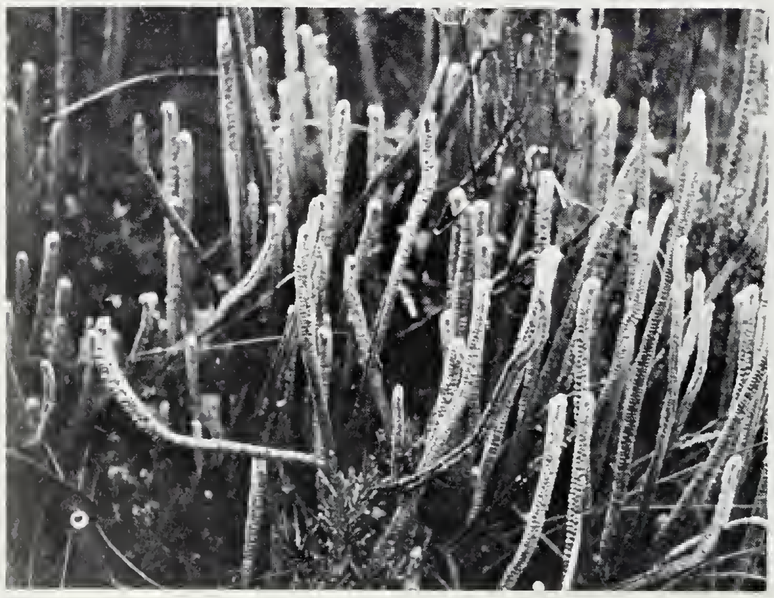


Fig. 4. *Jamesonia canescens* growing at 13,000 feet, above Mérida, Venezuela. Photograph by A. F. Tryon.

of precipitation each winter in the form of fog, fine mist and an occasional light rain. This is sufficient to develop the spectacular loma vegetation. During the winter months there is an almost continuous cloud cover over the coast, temperatures are mild to cool, and the climate is favorable for the development of a lush growth of plants.

Annual plants predominate and those with tubers and bulbs are common. There are some ferns of special interest in the loma flora. The most curious of these is the small *Anogramma leptophylla*, commonly called an annual fern because the conspicuous plant dies each dry season and develops again the following winter either from the persistent thallus (gametophyte) or from dormant spores. Two of the Adder's Tongue ferns also occur on Loma Lachay, 50 miles north of Lima. These are the diminutive *Ophioglossum petiolatum* and *O. nudicaule*. They belong to one of the most primitive groups of ferns (Ophioglossaceae); the leaf is undivided and the spores are borne on a specialized spike in large sporangia. The loma fern flora consists of about 15 species and, although these are rather unimportant in the vegetation, they are of special geographic interest. Most of the species of flowering plants on the lomas grow only in that habitat and many of them are restricted to a single loma. This is not true of the ferns for all of them are also known to occur at higher altitudes in the Andes. Fern spores are small and can be readily transported by air to the lomas, thus local populations of ferns have no opportunity to evolve in isolation. Most of the flowering plants are not so readily dispersed by seed and they can become isolated on a loma and new forms evolve.

The foothills of the Andes are high enough to be considered mountains in many parts of the world. They are dry and the aridity dominates the Pacific side of the Andes up to an altitude of about 8000 feet. A few of the desert (xeric) ferns appear here and they increase in number and abundance eastward in the moister altiplano. This is the high inter-Andean land of the sierra at about 11,000 to 14,000 feet, where 20 to 40 inches of rain occur each year. The effectiveness of the precipitation is vitiated by the rapid evaporation into the very dry air at the high altitudes. The general vegetation is dominated by bunch grasses, cacti (in great variety) and by xeric shrubs.

The ferns of the sierra occur locally in rocky places where their roots may have access to local seepage and to dew. Among about 20 species of xeric ferns in the sierra flora of Peru, one of the most

interesting is *Saffordia induta* (Figure 2). It grows only in Peru and no close relatives are known. Plants were first collected "in the mountain back of Lima," probably near Matucana in 1892, by the noted economic botanist W. E. Safford. They were not found again until 1954 when S. E. G. Saunders, an active collector who resides in Lima, discovered the species at Surco. More recently it has been collected in several other places. Mr. Saunders noted about his discovery of *Saffordia*: "When dry the leaves curl inward like a clenched fist, and conceal all of the green upper surface; after watering they open again." Other ferns of the dry parts of the sierra are Lip-ferns (*Cheilanthes*), Cloak-ferns (*Notholaena*), and Cliff-brakes (*Pellaea*), all familiar genera of ferns in the southwestern United States. Some of these in Peru, *Notholaena sinuata* (var. *sinuata*), *N. aurea*, *Pellaea ternifolia*, *P. ovata*, and *P. sagittata*, are the same as those in the United States. Others, such as *Cheilanthes myriophylla*, *C. farinosa*, and *C. notholaenoides*, grow in Mexico.

Ferns are usually conspicuous plants, especially in arid places where the vegetation is rather open. *Cheilanthes scariosa*, one of the Lip-ferns in Peru which inhabits limestone ledges, is well camouflaged. At a likely rocky place above Tarma no plants could be seen on the open limestone rocks at a distance of 15 feet. A closer approach revealed that they were plentiful, but the leaves grew erect, nearly appressed to the rocks (Figure 3) and they were completely covered by a dense investment of gray scales closely matching the color of the limestone. This species is unique among ferns in that the upper surface of the leaf is concealed by scales which grow entirely from the underside of the leaf.

The true mountains of Peru that may rise to 19,000 or even 22,000 feet are above the altiplano. The higher elevations are covered by snow and glaciers but plant life does extend to about 16,000 feet. Among the ferns of these high lands, the puna, the most characteristic is *Jamesonia* (Figure 4). This is truly an alpine fern with long, linear leaves, usually densely covered with tomentum, and with an apex that remains as a bud. These unusual features adapt the plants to the rigorous environment in which they live. This alpine environment in the tropics is perhaps even more demanding than that of northern mountains. There are great diurnal ranges of temperature so that the seasons are on a twenty-four hour cycle. Freezing occurs nearly every night and it can be hot during the day. In addition, the sunlight has a greater intensity at high altitudes and there is much more ultraviolet. The sierra ferns are especially interesting because they are variously modified for the extreme environments in which they grow.

Along the transect, after the Andes are crossed and the descent started into the valleys and slopes that lead to the Amazon watershed, the ferns become more abundant and more fern-like in appearance. Winds from the Amazon Basin press warm, humid air against the eastern flanks of the Andes and as the air rises along the slopes it is cooled and loses its moisture. The eastern Andes have the highest rainfall in

Fig. 5. *Polytaenium guayanense*, young plants on a small branch, collected near Tingo María, Peru, by R. M. and A. F. Tryon.

Fig. 6. Buds at the base of leaf-blade of *Doryopteris pedata* var. *palmata*.

Peru, ranging from about 80 inches to 140 inches a year. Ceja thicket occurs at the cool and moist higher altitudes (about 10,000 feet); or, in drier places, this is represented by the ceja scrub. Below is the montane forest.

A typical misty ceja thicket occurs on the road between Húanuco and Tingo María in the region called Carpish. Shrubs of the Heath family (Ericaceae) are common, a large thicket-forming bamboo (*Chusquea*) arches over the low woody growth and there is an occasional Tree-fern. Filmy-ferns (Hy-

Fig. 7. The Inca city of Machu-Picchu, looking toward the high mountains across the Río Urubamba. Photograph by A. F. Tryon.

Fig. 8. *Blechnum occidentale* growing on an Inca building at Machu-Picchu. Photograph by A. F. Tryon.

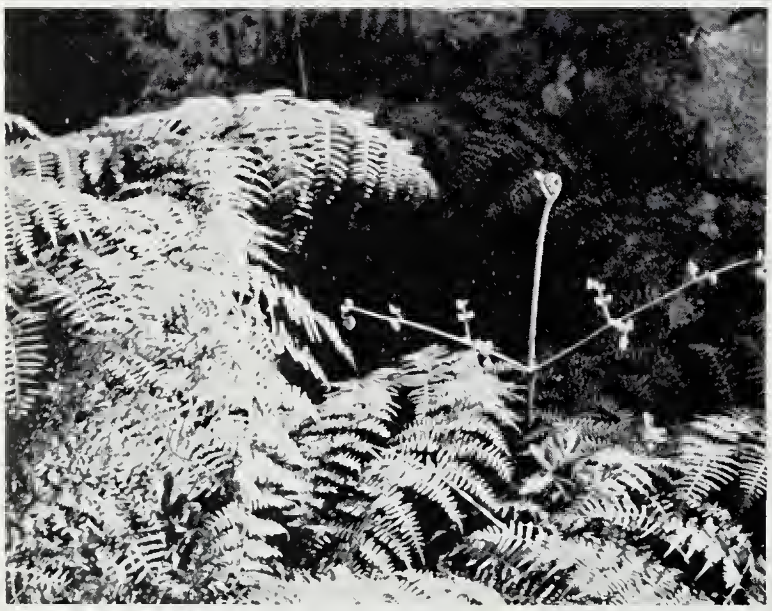


Fig. 9. The Bracken fern, *Pteridium aquilinum* var. *arachnoideum*, on agricultural terraces at Machu-Picchu. Photograph by A. F. Tryon.

menophyllaceae) are present and species of *Polypodium* and *Asplenium*. Most of the ferns are epiphytes, growing on the small trees and shrubs where they vie for a niche with the abundant liverworts and lichens.

In the large valleys that penetrate the Andes from the east, as the Chanchamayo valley above Huacapistana, there is a more gradual change from the aridity of the altiplano to the humid montane forest. A transition, the ceja scrub, consists of open shrubby growth and small, scattered trees. This is an especially important zone for ecological studies because sierra species reach their lower (most humid) limit in the same place that forest species reach their upper (most xeric) limit. The ferns reflect this vegetational change for the sierra types grow in the drier sites of the ceja scrub while, in moister places, are *Nephrolepis*, *Pityrogramma* and *Pteris* which are characteristic of the montane forest.

The montaña (forest) covers the eastern slopes of the Andes and all of the Amazon Basin. This is the richest region for species of ferns. They are especially numerous above 3,000 feet, in the montane forest, where the high rainfall and relatively cool temperatures are especially favorable. The steep slopes, canyons, and small ravines of the montane forest provide many rocky and open habitats for species, while the forests provide dense shade with tree trunks and branches available for epiphytes. This montane forest is especially rich in Maidenhair ferns. Twenty-five species of *Adiantum* grow in this region and they are often conspicuous elements of the flora. Epiphytic ferns are also prominent in the montane forest. Some of these are low epiphytes growing on the lower trunks of trees. Low epiphytes are often not restricted to trees, for some of the species of *Asplenium* and *Polypodium* also grow on wet rocks. These ferns usually have dissected leaves which are sometimes quite thin. High epiphytes are perched on branches of tall trees and are not readily collected. They are available on recently fallen branches, or logging operations bring them to easy reach as trees are felled. High epiphytes such as the Shoe-string fern (*Vittaria stipitata*) and *Polytaenium guayanense* (Figure 5) are obligate epiphytes. Their leaves are thickened and usually of simple form well adapted to the periodic drying which occurs in the branches of tall trees. Species of *Vittaria* have sticky spores, a feature that enables the plants to be more readily established on tree branches.

Another feature of the montane forest fern flora is the frequency of species with leaves adapted for vegetative propagation. Some of these, such as the

Halberd fern (*Doryopteris pedata* var. *palmata*), have buds on the leaf proper (Figure 6) which produce small plantlets when the old leaf falls to the ground. Other types have deciduous buds which are fleshy and produce a new plant when they drop to the ground. Still others have the apex of the leaf modified into a rooting tip somewhat like that of our native Walking fern (*Camptosorus rhizophyllus*). Although most ferns of the montane forest are relatively small ones, the region is notable for some with very large leaves. The largest of these are the frequent Tree-ferns (Cyatheaceae) which have crowns of leaves 6 to 10 or more feet long, borne on a trunk up to 30 feet in height. Another giant fern, *Diplazium marginatum*, has only a short stocky stem but has a spreading crown of leaves up to 10 feet long. *Adiantum pectinatum*, the largest of the Maidenhair ferns, has leaves up to 8 feet long and the leaf stalk (petiole) may be nearly an inch in diameter at the base. This remarkable Maidenhair sometimes forms shrubby growths along roadbanks. Plants of one of the Sword ferns, *Nephrolepis biserrata*, may have drooping leaves up to 12 feet long when growing on a steep slope. Other ferns such as *Hypolepis hostilis*, *Dicranopteris pectinata* and the Bracken (*Pteridium aquilinum* var. *arachnoideum*) form dense colonies with their strong creeping rhizomes and have leaves 5 to 6 feet long. The Bracken (see Figure 9) is one of the few ferns that ranks as an important weed due to its vigorous growth. The Cerro Azul, east of Tingo María, is one of the principal centers for tea culture in Peru. Here the hillsides are cleared in preparation for the tea, but if the plantations are not established soon enough, the Bracken invades the disturbed area and forms such a dense growth that the land must be abandoned.

The famous Inca fortress-city of Machu-Picchu (Figure 7) is a good place to observe ferns as well as to study the anthropology and architecture of this ancient site. It is perched on a high saddle of a steep ridge about 2500 feet above a sharp bend in the Urubamba River. Crevices between the stones of the buildings and the terrace walls provide ideal habitats for ferns such as *Blechnum occidentale* (Figure 8) and the Silver fern (*Pityrogramma tartarea*), while on the old agricultural terraces there are now "crops" of Bracken (Figure 9) and Adder's Tongue (*Ophioglossum reticulatum*).

In Peru, the Amazon forest occupies the lower portion of the montaña and the western part of the river basin. At Iquitos, Peru, about 1600 air miles from the mouth of the river, the elevation is only 350 feet above sea level. The rainfall is high, varying between 80 inches and 100 inches a year. The flora of the low Amazon Basin blends into that of the montane flora without any sharp line of distinction. An elevation of 3000 feet may be chosen to distinguish the two, for many plants grow mainly above, others mainly below this altitude. Palms, Aroids and Marantaceae are especially characteristic of the Amazon flora, as is the famous giant water-lily, *Victoria regia* (Figure 10), which grows in the quiet backwaters of the river.

Fig. 10. The giant water lily of the Amazon, *Victoria regia*, in a backwater lagoon of the river near Iquitos, Peru. Photograph by A. F. Tryon.

Fig. 11. Climbing-fern, *Lygodium volubile*, collected near Iquitos, Peru, by R. M. and A. F. Tryon. A sterile segment (pinna) attached to a portion of the leaf-axis which was 30 feet long; a separate fertile segment overlies the sterile one.

Some of the ferns characteristic of the low Amazon Basin are one of the Silver ferns (*Pityrogramma calomelanos* var. *calomelanos*), several species of *Thelypteris*, the Tree-ferns, and also the small aquatic fern *Salvinia rotundifolia*. This last has roundish floating leaves, less than a half inch in diameter; it is a relative of the "Green Menace" which has clogged Kariba Lake in Africa. Among the most unusual ferns of the Amazon forest is a Filmy-fern, *Trichomanes Hostmannianum*, which grows in places near the river that are inundated seasonally. When the river level falls, the leaves become covered with a thin layer of mud. The ability of this species to tolerate inundation makes it adaptable for use as an attractive submerged aquatic in fish tanks. Iquitos is a center for the tropical fish industry and exhibition tanks at the Department of Fisheries had this fern growing in them. Two Climbing ferns, *Lygodium volubile* (Figure 11) and *Blechnum volubile*, have very long leaves that reach 30 or more feet into the trees. These appear to be vines but the stem (rhizome) remains in the ground around the base of the tree while the leaves climb the trunk. The ferns of the forest are not as numerous as the montane regions but they are abundant in old clearings and along forest borders. While these are recent and artificial habitats, they duplicate naturally disturbed sites such as riverbanks, borders of sloughs and swamps, and forest openings created by the fall of large trees.

Boats are the main form of transportation around Iquitos for there is no road system through the country. The Raimondi (named after the Italian naturalist) is one of the famous boats used by the Department of Fisheries. The crew of this boat was typical of the alert river people of Peru, who appreciate the importance of the environment upon which their lives depend. They were much interested in observing the methods of collecting, and the kinds of plants. They would bring additional specimens of the same species, even in difficult groups of ferns that look much alike, and they never made a mistake in identification. When excess material of epiphytic *Polypodium* and *Asplenium* species was gathered, they would carefully place the mats back on the trees from which they came.

Biogeography of Andean Ferns

Some of the ferns that have been studied in detail reveal complexities in their geographic and evolutionary history. The desert ferns provide excellent evidence of recent migration along the high and xeric altiplano of the Andes. Figure 12 presents diagrammatically the area of high specialization of *Pellaea* and *Notholaena* which centers on Mexico, and the South American distribution of some of the species that also occur in the Andes: *Pellaea ovata*, *P. sagittata* (var. *sagittata*), *Notholaena aurea*, and *N. sinuata* (var. *sinuata*). These are specialized xeric ferns that have evolved in the arid regions of Mexico where their close relatives also grow. They have migrated southward through the Andes to Bolivia and Argentina. In contrast, a northward migration along the Andes is indicated for the genus *Doryopteris*. These attractive ferns usually grow in moist places where the soil is well drained. Figure 12 shows the central area of *Doryopteris* in southeastern Brazil, where there are 20 species (including the most primitive ones), and the northern portion of the range where 7 species occur. These two areas are connected by the ranges of 6 species in the Andes from Bolivia to Columbia. In contrast to the xeric species of Mexico, which grow in the arid parts of the altiplano, the species of *Doryopteris* occur along the eastern flanks of the Andes in moister situations.

An older migration, this time again from the north, may be seen in a small group of Tree-ferns (Cyatheaceae) belonging to the group of *Sphaeropteris horrida*. The two most primitive species grow

Fig. 12. The Andes as a route of migration. Southward migration of xeric ferns of Mexico (solid lines). Northward migration of *Doryopteris* (dashed lines). Arrows have been placed to the side of the Andean migration path (see text for further explanation).

in the Greater Antilles, Mexico, and Guatemala; the next most primitive species grow in Costa Rica and Colombia; a more advanced species extends from central Colombia through Peru to Bolivia; and the most highly evolved one grows in southeastern Brazil. The concomitant migration and speciation of this group has proceeded in an exactly opposite direction from that in *Doryopteris.*

While the Andes have been an important migration route, they have also provided ideal circumstances for the evolution of groups within the mountains themselves. One of the best examples is the alpine fern *Jamesonia* previously noted. This genus is closely allied to another, *Eriosorus*, growing at lower altitudes, and usually with more dissected and fern-like leaves. *Jamesonia* is clearly an alpine derivative of *Eriosorus* and it has been a successful evolutionary development. There are 19 species of *Jamesonia* in the Andes and a few have spread to mountains in Central America and to Mount Itatiaia in southeastern Brazil. Other ferns that have centers of speciation in the Andes are *Pityrogramma* with 13 of 18 American taxa Andean, and a group of the Filmy-ferns (*Hymenophyllum* section *Sphaerocionium*) with slightly over half of the 52 American species in the Andes.

Cultivated Ferns

The ferns of the Andes and Amazon have been widely cultivated for their attractive foliage. An effort was made to obtain materials for cultivation in British and European greenhouses beginning with the earliest plant explorers. Extensive collections of living tropical American ferns were developed, especially at Kew, Leipzig, and Berlin. In the first half of the 19th century, fern cultivation became generally popular through the development of the Wardian Case and nurseries vied with each other to obtain new and rare tropical species for the market. Special collectors were sent to the Andes and many of the most popular ferns were introduced through the work of these botanists. Many variations of two Maidenhair ferns, *Adiantum Poiretii* and *A. Raddianum*, were introduced as were several of the Gold and Silver ferns (*Pityrogramma*), with yellow or white wax on the leaves, as well as many kinds of Spike-moss (*Selaginella*). Although interest in fern growing is not now as intense as it was in the Victorian period, many of the species and cultivated variations are still popular today.

Medicinal Ferns

The coastal civilizations of Peru had vanished by the time of the Spanish Conquest and the Indians of the Amazon forest did not have a high culture. It was the Inca peoples of the sierra, the most advanced group in the Andean regions, that utilized ferns in their medicine. Some of the ferns mentioned by the earliest Spanish chroniclers are still to be found for sale in the markets today, especially at Huancayo, Pisac, and Cuzco. Calaguala (*Polypodium angustifolium*) is used as a purge and in the treatment of malaria; Puntu-puntu (*Polypodium crassifolium*), for pains; and Kumu-kumu (*Asplenium monanthes*), as a diaphoretic. Some of the xeric ferns abundant in the Inca heartland and used medicinally are Cuti-cuti (*Notholaena aurea*) for dropsy, Cuti-cuti-blanco (*Notholaena nivea*) as a sudorific, and Inca-cuca (*Cheilanthes incarum*) for bronchitis. Abundant mucilage is obtained from the stem and leaves of the Tree-fern Sano-sano (*Nephelea cuspidata*) and stored in an open joint of bamboo. It is disolved in water and used as an ointment for swollen joints and broken bones.

Conclusion

The history of evolution of plants and animals and their migration into and within South America is an intriguing study that has fascinated naturalists since the fundamental discoveries of Charles Darwin. It is now well established that living species have evolved from previous ones which often grew in other places or in different environments. One of the principal objectives of naturalists is to trace these changes so that the complex history of life may be better understood. The ferns are an integral part of the floristic developments in South America and their study has provided insights into some of that history.

FERNERY

The Fernery will be open regularly from 1 to 2 p.m. each week day. Special arrangements can be made for other times.

Announcements for Associates

NEW ACTING DIRECTOR

Dr. Hui-Lin Li, Professor of Botany, Curator of the University Herbarium, and Taxonomist of the Morris Arboretum has been appointed Acting Director, beginning January 1, 1971. Dr. A. O. Dahl resigned as Director December 31, 1970, and is now on academic leave.

WALKS AND TALKS

We are pleased to announce a series of tours of the Arboretum grounds. A guide will accompany Associates and discuss interesting aspects of the garden as the seasons change.

This Spring, the walks will be on the third Saturdays of the month from 10 to 11:30 a.m. as follows:

April 17, Spring-flowering Trees and Shrubs
May 15, Azaleas and Rhododendrons
June 19, Specialty Gardens

All groups will leave Gates Hall, 9414 Meadowbrook Avenue, promptly.

SHORT COURSES

Announcements of a new series of non-technical courses on basic botany and practical horticulture designed for the Associates of the Arboretum and the general public were sent out early in 1971. Each course consists of six sessions of 90 minutes each (with a short recess midway), and combines lectures, demonstrations, and practical experiences. Classes meet in Gates Hall from 10 to 11:30 a.m.

The registration fee is $25 per course for Associates, $30 for others.

S 1 ORGANIZATION AND FUNCTION OF PLANTS. DR. H. L. LI.
An introduction to the structures of flowering plants, how the different parts carry on their functions, and how the plants live in their environment.
Mondays, 10-11:30: March 29, April 5, 12, 19, 26, May 3.

S 2 CLASSIFICATION AND IDENTIFICATION OF PLANTS. DR. A. E. SCHUYLER, ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.
General principles of classifying and naming flowering plants; ways of identifying plants by using keys, manuals, floras, and the herbarium.
Tuesdays, 10-11:30: March 30, April 6, 13, 20, 27, May 4.

S 3 MOLDS, MUSHROOMS, AND THE ENVIRONMENT. DR. PATRICIA ALLISON.
What important fungi look like; how they interact with their surroundings and change the lives of other creatures.
Wednesdays, 10-11:30: March 31, April 7, 14, 21, 28, May 5.

S 4 PLANT PROPAGATION I. ANGUS PAXTON HEEPS.
Basic procedures of propagation by seed and vegetative parts. Particular attention will be paid to those plants which can be propagated during the Spring and Summer months.
Thursdays, 10-11:30: April 1, 8, 15, 22, 29, May 6.

PLANT DISTRIBUTION DAYS

Friday, May 21, 10-4 p.m., and Saturday, May 22, 10-12 noon have been set aside for distribution days. Detailed announcements will be mailed to Associates as usual.

THE LAURA L. BARNES LECTURE

The annual Laura L. Barnes Lecture will once more be given in the Spring. As in the past, separate announcements will be mailed.

The Morris Arboretum Monographs

A SERIES OF SCHOLARLY WORKS ON BOTANY AND RELATED SUBJECTS

Unless out of print, books are available postpaid from the Morris Arboretum, if remittance accompanies orders.

The Beginnings of Plant Hybridization. Conway Zirkle. 1935. 231 pp. University of Pennsylvania Press. (Out of print)

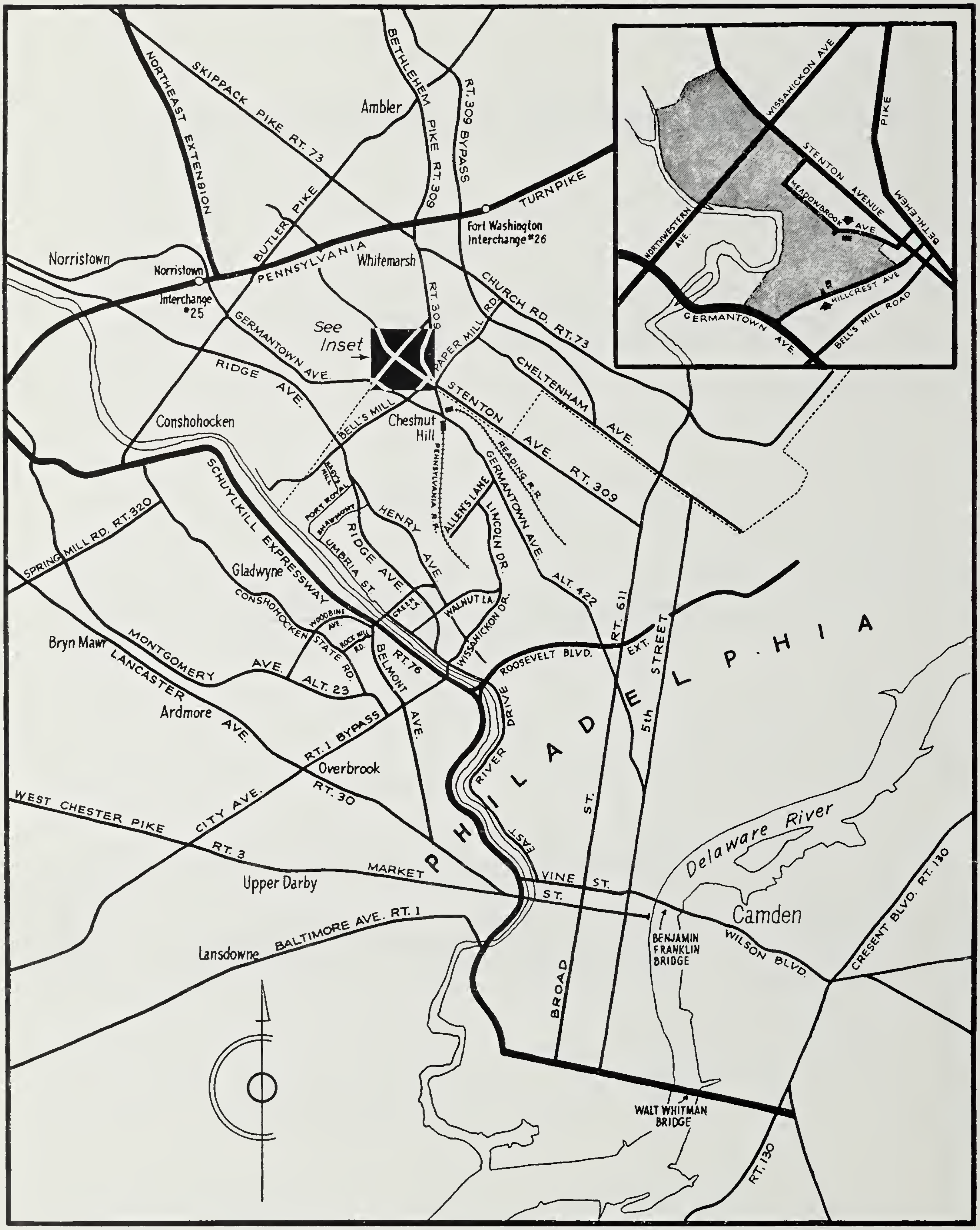
Conservation of Renewable Natural Resources. University of Pennsylvania Bicentennial Conference. Raphael Zon et al. 1941. 200 pp. $7.50 University of Pennsylvania Press. Reissued, 1969, by Kennikat Press, N. Y.

The Genus Phlox. Edgar T. Wherry. 1955. 174 pp. $4.50. The Morris Arboretum.

Woody Flora of Taiwan. Hui-Lin Li. 1963. 974 pp. $18.75. Livingston Publishing Co., Wynnewood, Pa. and The Morris Arboretum.

A Selected Guide to the Literature on the Flowering Plants of Mexico. Ida Kaplan Langman. 1964. 1015 pp. $22.50. University of Pennsylvania Press.

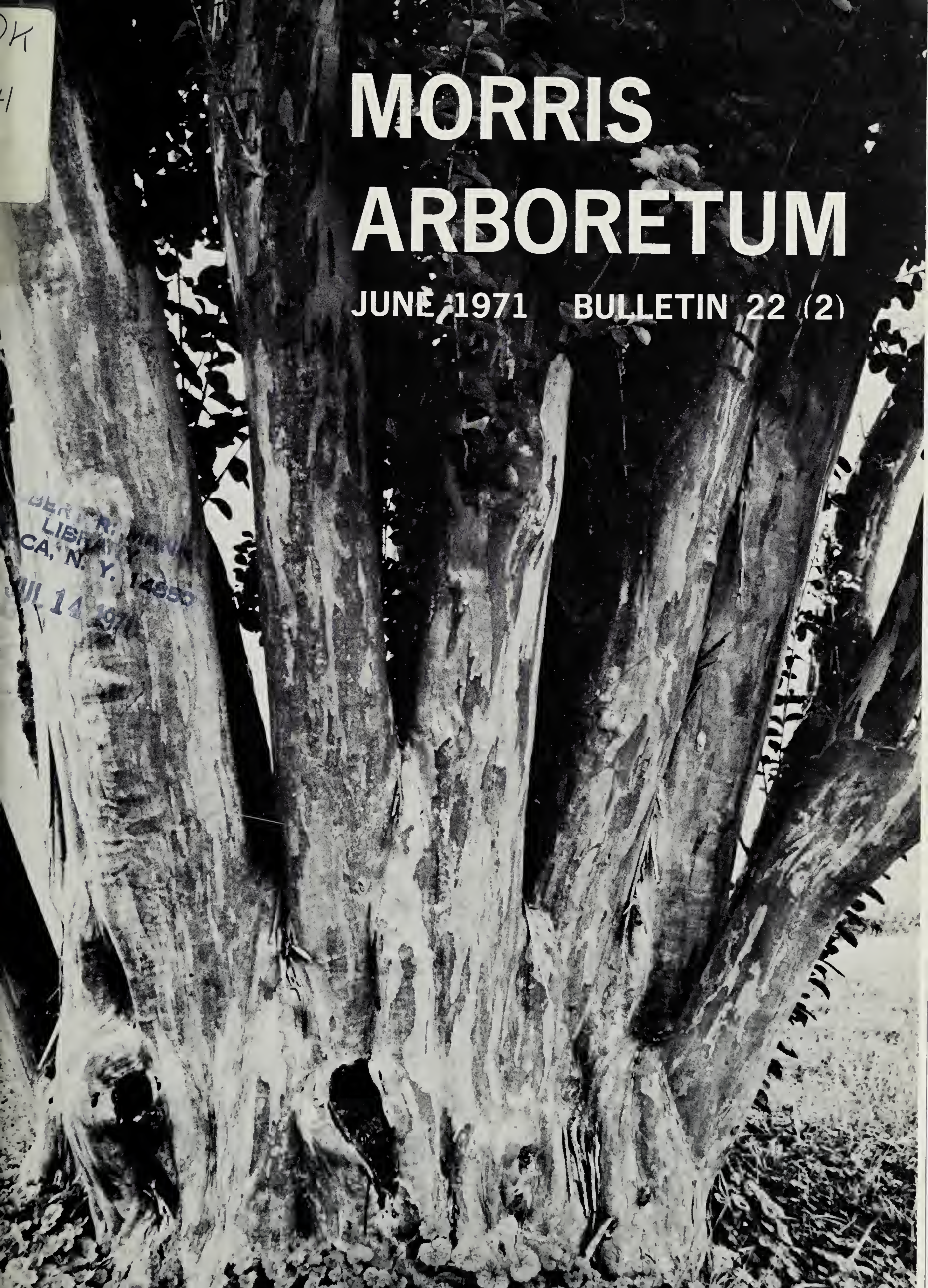
Floristic Relationships Between Eastern Asia and Eastern North America. Hui-Lin Li. 1952. Reprinted with a foreword bringing the literature review to 1971. 60 pp. $3.75. The Morris Arboretum.



MAP SHOWING ACCESS TO THE MORRIS ARBORETUM, PHILADELPHIA, PA.

MORRIS ARBORETUM

JUNE 1971 BULLETIN 22 (2)



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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

TYPES OF MEMBERSHIP

Contributing	$10.00 a year	Supporting	$25.00 a year
Family	$15.00 a year	Sponsoring	$100.00 a year
Donor	$500.00		

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PLANTS COMMEMORATING PERSONS. II.

LAGERSTROEMIA, THE OPULENT CRAPEMYRTLES

DONALD R. EGOLF[1]

INTRODUCTION

The "Lilac of the South," *Lagerstroemia indica* L., has been extensively cultivated and has been a symbol of southern grandeur for more than a century and a half, from Colonial plantation days to the present. "Crapemyrtle," the common name for *L. indica*, was propagated and transplanted to new frontiers by our forefathers to brighten the historic ante-bellum gardens as well as the doorsteps of the most forlorn shanties. Like the lilac, *Syringa vulgaris* L., the plant often survives to mark the cellar holes of bygone mansions, the abandoned cemeteries, or the frontier paths trodden by those who molded the history of the Nation. Crapemyrtle, although an introduced plant, has naturalized in certain areas and has become a plant associated with southern gardens in much the same manner that the lilac is a plant for northern gardens.

The genus *Lagerstroemia* belongs to the family *Lythraceae* and is composed of more than 50 species of trees and shrubs which are distributed chiefly from Southeast Asia to Australia. The genus occurs in China, Japan, India, Burma, Indochina, Thailand, Malay Peninsula, Indonesia, Celebes, Borneo, New Guinea, North Australia, and the Philippine Islands. Furtado and Srisuko (1969) described 12 new species and 13 new botanical varieties in *A Revision of Lagerstroemia L. (Lythraceae)*. The largest number of species are tropical and are adaptable to cultivation in the United States only in the warmer areas of Florida and California. Not all species have showy, ornamental flowers, and many have rather inconspicuous, small, pale white to lavender flowers. Some species yield valuable timbers such as benteak or venteak (India) from *L. microcarpa* Wight(syn., *L. lanceolata* Wall.); lendia or bondárá (India) from *L. parviflora* Roxb.; banaba (Philippines), Jarul (India), or pyinma (India, Burma) from *L. speciosa* (L.) Pers.; batitinan, natjuba, or Philippine teak (Philippines) from *L. piriformis* Koehne; and adaman pyinma (India) from *L. hypoleuca* Kurz. Crapemyrtle wood, which brings premium prices on the world market, is hard, very strong, durable, elastic, heavy, and similar in appearance to teak. It is used in naval construction, framing houses, furniture, telephone poles, plywood, and piles. Tannin is extracted from *L. microcarpa*, *L. parviflora*, and *L. speciosa*. Charcoal made from *L. indica* is used in Japan for thickening lacquer. The Atlas silkworm moth (*Atlacus Atlas* (L.)) and the Indian tussur silkworm moth (*Antheraea mylitta* (Drury)) feed on the leaves of *L. parviflora* and *L. indica*. The many vernacular names for the wood as well as for the plant are very confusing and variable in different geographical areas, (Ahern, 1901; Burkill, 1935; Council of Scientific and Industrial Research,

Fig. 1. "Tsjinkin" (Tzu Wei) and the small Indian mongoose, published by the naturalist Rumphius in *Herbarium Amboinensis Auctuarium*, Tab. 28, 1755. The plant shown in this illustration, along with the accompanying description of "Tsjinkin," was recognized and named *Lagerstroemia indica* by Linnaeus in honor of his patron, Lagerstroem.

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New Delhi, 1962; Gamble, 1881; Parkinson, 1931; Whitford, 1911).

The crapemyrtle derives its name from the crinkled and ruffled petal blades at the end of the long claw and the resemblance of the leaves to the true myrtle, *Myrtus communis* L.

Since *L. indica* is the species most frequently cultivated in the United States, it will be discussed in the greatest detail. It is a deciduous shrub or small tree that may attain a height of more than 30 feet. The numerous ascending branches have very thin, smooth, light brown bark which peels in long shreds to reveal a mottled trunk. The leaves are 1-3 inches long, elliptic or obovate to oblong, rounded or blunt, short-petioled, glabrous, and often garnet-tinged when young. The showy, terminal and lateral, 6-18 inch long panicles of flowers, generally of some shade of white, pink, red, mauve, or lavender, are borne from late June or July until early fall. The flowers are 1-2 inches in diameter and have 6 petals which consist of a more or less rounded blade, crepe-like crinkled, and with a long, slender claw. The numerous stamens, inflexed in bud and inserted near the base of the calyx tube, are brilliant yellow, in sharp contrast to the colorful petals. The seed capsule is almost globose, less than half an inch in diameter, and surrounded by the calyx; it contains many compressed, imbricate seeds. Although the plant is considered a native of China, it is questionable whether the true native habitat could now be delineated since the species has become so widely naturalized throughout all temperate and tropical regions.

Crapemyrtle was figured and described by G. H. Rumphius, a Dutch physician in the service of the Dutch East Indies Company, in *Herbarium Amboinensis Auctuarium*, 1755, under the Chinese name "Tsjinkin" as rare in India, abundant in the mountains of China, and cultivated around temples. (It is quite likely that he transliterated the Chinese name Tzuchin, used for *Cercis*, by mistake.) The captains of merchant ships that docked at the East Indies ports could not resist the majestic floral display of crapemyrtle and were inspired to collect and further disseminate the plant. Linnaeus described *L. indica* in 1759 (Linnaeus, 1759) from a specimen presumably obtained by these means from Magnus von Lagerstroem.

Lagerstroem and Linnaeus

The genus *Lagerstroemia*, a beautiful tree known to the Chinese as Tzu Wei and already described and illustrated by Rumphius, was named by Linnaeus for his friend, the ardent naturalist, Magnus von Lagerstroem. Lagerstroem was born December 16, 1696, to a prominent Swedish family in Stockholm. Although his education had prepared him for a business career, he became a patron of the natural sciences. He was appointed Director of the Swedish East Indies Company at Göteborg, which permitted him to pursue his love of nature while gainfully employed. He ordered the captains in the service of the East Indies Company to keep diaries of meteorological, physical, and geodesic observations; the passengers to keep logs concerning the customs, language, and dress of the people visited; and the physicians to devote research to the natural resources, including plants, and to deliver them to the Mother Country. Lagerstroem's position enabled him to procure many rare objects of natural history from India and China which were sent to the Royal Academy of Sciences in Stockholm and to the Royal Society of Uppsala. He succeeded in introducing seeds and plants from those distant lands into the Uppsala Botanic Garden. Also, among his importations was a collection of about 1,000 Chinese drugs. It was from the herbarium specimens, seeds, and plants that Linnaeus rendered illustrations and descriptions. Because of his renowned contributions to the natural history of Asia, Lagerstroem was made a member of the Stockholm Academy of Sciences and the Uppsala Royal Society. He died in 1759 and his natural history benefaction was commemorated by the genus *Lagerstroemia* in the same year.

Carolus Linnaeus was born on May 13, 1707, in Rasbull, Sweden. Following his appointment as demonstrator and a year later as Docent in Botany at Uppsala University, he published *Hortus Uplandicus* and a later revision which classified the plants in the Uppsala Botanic Garden according to his so-called sexual system. In 1737, he went to Germany and Holland, where he received his M.D. degree from the University of Haderwijk. His manuscript *Systema naturae*, which provided a foundation for classification of all plants, animals, and minerals, was published by Dr. Jan Fredrik Gronovius, a physician and naturalist who was much impressed by the young Linnaeus. Linnaeus was hired as physician for Mr. George Clifford, Director of the Dutch East Indies Company, and to identify all the plants growing on his estate, "Clifford." While his patron was publishing in late 1737 his works *Genera plantarum* and *Flora Lapponica*, Linnaeus was sent to visit botanists and botanic gardens of England. On his return, *Hortus Cliffortianus* was published in which were named and described many temperate and tropical plants grown at Clifford. Upon his return to Stockholm, Linnaeus established a medical practice and was appointed physician to the Admiralty. In 1741 he was appointed to the Chair of Medicine at Uppsala University, a position he held until 1775. His *Species*

plantarum, published in 1753, has been the accepted starting point of present-day nomenclature and the basis of systematic classification of vascular plants. In recognition of this and his earlier works, Linnaeus was knighted (1753) and later (1761) granted a patent of nobility, from which later date he was known as Carl von Linné. He died January 10, 1778.

History of Cultivation

Crapemyrtle has been a widely and commonly cultivated ornamental tree in China from very early times. It was first grown in England at Syon House, near London, more than 200 years ago by His Grace, Hugh, the 2nd Duke of Northumberland, who is credited by Aiton (Curtis's Bot. Mag., 1798) with the introduction of this plant to the Royal Botanic Gardens at Kew in 1759. The route of introduction taken by this Asiatic plant to Colonial America is obscure, whether from Europe, or directly from the Dutch East Indies. André Michaux who was sent by the French Government to investigate North American plants for their introduction into France, and who established a nursery near Charleston, South Carolina, in 1786, apparently was responsible for the first crapemyrtle introduction in that area. However, we have been unable to locate any specific record of introduction by Michaux.

It is very probable that the Charleston area was not the first Colonial seaport to admire the profusely flowered crapemyrtle. Fine old specimens are to be found in many of the historic gardens from Virginia southward. According to records at Mount Vernon, George Washington's plantation, there were aboard the ship *George Barclay* that arrived in Philadelphia in April 1799, two plants and seed of *L. reginae* Roxb. and seed of *L. indica* from the East Indies destined for Mount Vernon (Fisher, 1971). However, *L. reginae* is a tropical species that would not survive the rigors of Virginia winters, and no record of survival of the plants or seeds of either species has been found. Since General George Washington was instrumental in acquiring seed of *L. indica* in 1799, it is regretted that Mount Vernon today has only three crapemyrtle plants. The Mount Vernon Ladies Association of the Union introduced crapemyrtle to Mount Vernon in the late nineteenth century, only to have it removed from the exhibition area in 1917 at the direction of Charles S. Sargent, then Director of the Arnold Arboretum, Jamaica Plain, Massachusetts, and consultant to the Association. Prof. Sargent's justification for the elimination of crapemyrtle was that they were not at Mount Vernon during George Washington's lifetime.

Another clue of a possible northern introduction is that *L. indica* plants were offered for sale in 1827, and possibly earlier, by the Prince Nursery, Flushing, L.I., New York. This nursery, which was founded in 1737 and was probably the largest in terms of United States introductions of new, rare, and also common plants, claimed to have direct importations from China (McGourty, 1967). Records from Rosedown Plantation, St. Francisville, Louisiana, include invoices for plants obtained from the Prince Nursery, which undoubtedly dispersed plants to many antebellum homes and gardens of the South developed in the first half of the nineteenth century. Crapemyrtle

Fig. 2. Specimen crapemyrtle in the formal boxwood garden at Equitable Life Insurance Company, Washington, D.C.

was listed among the plants cultivated in the Elgin Botanic Garden, New York, in 1811 (Taylor, 1952). *L. indica* was offered by James L. Warren and Son of Sacramento and San Francisco in 1853 (Butterfield, 1964), possibly the first introduction into California. Col. Warren, who had traveled abroad and had previously operated Nonantum Vale Nursery, near Brighton, Massachusetts, arrived aboard the ship *Sweden* in San Francisco in 1849 (Butterfield, 1966a), and possibly crapemyrtle was included in his cargo. The source of introduction to California is obscure, but it is plausible that the route was from

the Eastern United States as pioneers migrated across the Continent, or, as Butterfield (1966b) suggests, that plants or seed were shipped from the well established Eastern nurseries. It is noted that firms such as Prince Nursery did dispatch plants to California. However, the pathway to introduction may have been from Asia through one of the California seaports. Possibly a northern nursery deserves credit for crapemyrtle introduction into the United States, rather than a southern point such as Charleston. Present evidence is insufficient to establish when crapemyrtle was introduced into America, or by whom; but it could have been through any of the prominent Colonial Eastern ports of the late eighteenth century, or directly from Asia to California.

In a review of literature such as that by Christian (1953), Cooney (1933), Henderson (1939), Lockwood (1934), Sale (1923), Shaffer (1963), Slosson (1951), and others that recorded the historic Colonial estates, gardens, and their contents, there are frequent references to crapemyrtle. Although some of the landmark specimens have vanished due to fire, neglect, vandalism, highway construction, and modern industrial or residential developments, many stately specimens have withstood the rigors of time to reflect the glories of past centuries. Fortunately, a number of specimens have been preserved by the efforts of garden clubs, civic groups, and individuals who have been actively engaged in the restoration of Colonial America; and some of these are included in the appended list of gardens.

Mammoth crapemyrtle specimens with gnarled and twisted trunks are frequently observed in old cemeteries, near early churches, adjacent to eighteenth or nineteenth century mansions, or towering over the simplest of rural dwellings. Several states, as well as the American Forestry Association, maintain a record, or "Social Register," of the crapemyrtle champions. In order to give an indication of size attainable, measurements are given for several of the real "grand-daddies." The champion of South Carolina, which must be a single trunk plant, is located at the residence of Mrs. Charles C. Cutts, Conway, S. C., and has a trunk girth of 6 feet 1 inch at 4 1/2 feet from the ground and a crown spread of 40 feet (S.C. Coop. Ext. Serv., 1970). The specimen in the American Forestry Association Social Register is located at Middleburg Plantation, Huger, S. C.; has a trunk girth measurement of 9 feet 8 inches at 3 feet above ground level; is 58 feet high; and has a crown spread of 50 feet (Dixon, 1961). A large specimen at Claremont Manor, Claremont, Virginia, has a trunk girth measurement of 7 feet 6 inches at 4 1/2 feet from groundline. Size measurement of multi-stemmed specimens becomes more difficult because of the number of trunks and their diameter. One of the largest, if not the largest, multiple-stemmed specimen is located at Denbigh Plantation, Denbigh, Virginia. It has 7 trunks with the largest 4 feet 6 inches in girth and has a height of 45 feet. Unfortunately, this magnificent specimen has suffered from years of neglect and now is in the shadow of impending destruction by the encroachment of a modern housing development. At Rose Hill, Suffolk, Virginia, there is a 14-stemmed specimen 35 feet tall that has a girth of 18 feet at 4 1/2 feet above groundline. Another specimen of great age, possibly as much as 150 years, and enormous size is located at Stratford Hall, Stratford, Virginia, the birthplace of General Robert E. Lee. This specimen has 15 trunks, a girth of 32 feet 5 inches at 4 1/2 feet above ground level, a height of approximately 38 feet, and breadth of 42 feet. This plant in recent years has suffered from winter winds that have partially damaged the topmost branches but it still remains a most imposing specimen located at the rear of the old kitchen and to the right of the walk leading to the mansion. One of the very largest specimens has been reported growing at Borough House, Stateburg, South Carolina, but current measurements are not available. Commonly, the crapemyrtle is classed as a shrub, but with age it may become a small to medium-sized tree adaptable to many landscape uses.

Landscape Uses

The landscape attributes of crapemyrtle are not restricted to a flamboyant seasonal floral array in shades of red, pink, lavender, and white, but are emphasized throughout the year with sinuate, mottled trunks, garnet-tinged leaves and shoots, and autumnal leaves with shades of yellow, orange, and red. Crapemyrtle in past decades has been held in esteem for its brilliant summer flowers. Today the plant is revered as much for the picturesque trunk and strong branching pattern as for its floral display. The trunk is further enhanced by the annual, early summer exfoliating bark that reveals the smooth, light pinkish tan to pale green, mottled coloration of the new bark. It is the bold, sinuate trunks and not the flowers that are highlighted in the extensive formal garden at Chippokes Plantation State Park, Surry, Virginia. A single plant well positioned could well become the focal point of a small garden or an exciting accent to an evergreen background planting, a wooden fence, or masonry wall. The tree types are scaled for the expanse of large estates or parks, or as specimen small trees for the modern residential property. The dwarf and more shrubby types can be pruned judiciously to control size are suitable for residential planting, and also are adaptable to bedding

Fig. 3. Within the formal gardens at Chippokes Plantation Park the canopy of flowers and foliage is barely visible, but it is the beautiful, sinuate, multi-colored, mottled trunks highlighted by the filtered light that are the focal points.

and ground cover planting. The diversity of color and growth habit of cultivars provides the landscape architect and gardener with a shrub amenable to many unique specifications.

The cultivation of crapemyrtle need not be restricted to those southern gardens with adequate area for specimen plants; they may be grown, within limitations, in containers. The plant was first cultivated as a conservatory plant when introduced into England and still will be found in greenhouses in Europe. By growing plants in various types of containers, the crapemyrtle may be used for a multitude of decorative purposes, from private balconies and patios to public parks and congested shopping centers. For container culture the requirements are the same as for outdoor planting—low to only moderate soil fertility, good drainage, abundant sun, free air movement, and adequate water. The northern garden enthusiast could impress his neighbor by maintaining container plants overwintered in a garage, basement, or greenhouse. It must be remembered, however, that the cooler summer temperature and shorter growing season in many northern areas limit even the successful container growth of some cultivars outdoors.

The planting along street and highway is one of the greatest landscape uses of crapemyrtle. Since the ultimate height is that of a small tree, it is ideal for streets with low overhead wires. The California Association of Park Administrators has listed crapemyrtle as one of the 65 trees suitable for parkway planting in Southwestern United States. Such recommendations have been pursued in other States. Street and highway beautification planting utilizing crapemyrtle often has been sponsored by garden clubs, civic groups, school children, local and State governments. Some early notable plantings are as follows: Center Main Street, on Highway #258, Scotland Neck, North Carolina; Main Street, Nashville, North Carolina; Rocky Mount Rt. in West Edgecombe Community, North Carolina; south side of Old Shell Road, Mobile, Alabama; streets in Savannah, Georgia; U.S. Highway #13 in Northampton County, Virginia; Aberdeen, Mississippi; Natchez, Mississippi; Sumter, South Carolina; Houston, Texas; Dallas, Texas; Beaumont, Texas; San Gabriel Valley, California, and most abundantly in Norfolk, Virginia.

The extensive crapemyrtle planting program instituted in the latter city by Mr. Fred Heutte, former Superintendent of Parks, some 30 years ago deserves

Fig. 4. Mammoth, multiple-stemmed, light pink crapemyrtle at the edge of the lawn at Claremont Manor.

special mention as it has virtually converted the Norfolk industrial complex into a crapemyrtle capital. Ballantine Boulevard, the marginal airport fringe, and the Norfolk Botanic Garden are but three of the many points within the city that have been beautified with more than 40,000 plants. The established highway beautification programs have vividly demonstrated the crapemyrtle potential which is now being duplicated in many other communities.

Hardiness

Lagerstroemia indica, *L. fauriei* Koehne, and *L. subcostata* Koehne are reliably hardy in Zone 7b,[2] while isolated plants have survived in Zone 7a. This places the guaranteed northern limit in the vicinity of Washington, D. C., Maryland, Virginia, Tennessee, Arkansas, Oklahoma, Texas, New Mexico, Arizona, and California. The more tropical species, such as *L. speciosa*, *L. tomentosa* Presl, *L. floribunda* Jack., etc., are largely restricted to Zone 10b or the warmer parts of Florida and California. On the wetter coast of California and in the San Francisco Bay area crapemyrtle is quite susceptible to mildew; however, it luxuriates in the warm, dry interior valleys of most of California and in Arizona desert areas with long growing seasons and high summer temperatures when well watered. At higher elevations, more than the winter cold, the cooler summers and shorter growing seasons limit its performance. In the Eastern United States along the Jersey Coast and Long Island, it grows as a small, less hardy shrub. Cape Cod, Massachusetts, and Aurora, Oregon, are two of the northernmost localities for top-hardy crapemyrtle to survive. Although Zone 7 is considered the dividing line of hardiness, it is not implied that plants cannot be grown outdoors in a colder zone. Such plants may grow, flower, and survive the winter uninjured, but their growth will not equal the more luxuriant growth and profuse flowering of plants in Zone 7b or farther south. Nor can even less hardy cultivars, top-killed to the groundline each season, produce the same ornamental display as those that encounter no temperature and photoperiod limitations. There are many clones that may be root hardy, especially if mulches: but this does not warrant being called "hardy." Is it not more logical to plant a cultivar that is adapted to such conditions rather than try to superficially acclimate one that may or may not reward the owner with a season of bloom? As crapemyrtle is responsive to temperature and light intensity for flower initiation, one could expect a plant transplanted from a southern latitude to a more northern latitude to respond differently. Hopefully, the day will come when crapemyrtle will be available in broad variety to gardeners beyond Zone 7. Because of the time and length of blooming period, gardeners in the northern zones would welcome crapemyrtle even more than southern gardeners would cherish an adaptable lilac that required no cold treatment in order to flower abundantly. In any case, the avid northern gardener should not be discouraged from attempting to grow a specimen crapemyrtle, but he would be forewarned that his success cannot compete with the success of his southern counterpart.

Records are known of a number of sizable specimens in the Philadelphia area. Sixty miles north of Philadelphia, at Allentown, a fine pink-flowered specimen is 30 years old. Plants also are thriving at the Reading Public Museum, Reading, Pennsylvania. At the Masonic Home in Elizabethtown, Pennsylvania, a white-flowered specimen some 30 years old is 12 feet tall. Even farther west at Waynesboro, Pennsylvania, in Zone 6, specimen plants have had

Fig. 5. The pink crapemyrtle to the rear of the old kitchen at Stratford Hall is of enormous size and possibly 150 years old.

[2] Plant Hardiness Zone Map, U.S.D.A. Misc. Publ. No. 814, 1960.

little winter injury. These are but a few indications that crapemyrtle can be successfully grown in a northern location if plants of adequate size are planted and maintenance care is provided. It is possible that through such trial and error, and by thorough observation of resultant northern seedlings, a more hardy crapemyrtle may be selected.

Culture

The proper planting site promotes flowering, controls mildew, and avoids winter damage. Crapemyrtle flowers only sparsely in partial shade and not at all in heavy shade. It is a plant that thrives in sun and heat provided adequate moisture is available. A slightly elevated position will insure air drainage and greatly alleviate any serious mildew problem, while a planting site adjacent to or near water provides for greater mildew damage. A protected location such as a courtyard may be advantageous, while planting near masonry or glass walls may be disastrous, especially in the more northern hardiness limitations. The wall radiates heat thereby promoting soft growth that is subject to winter injury. Likewise, planting near a building restricts air movement and consequently promotes mildew. In the deep South crapemyrtle may survive, although less floriferous, and become subject to heavy mildew infection when it becomes entwined with Spanish moss. The ideal planting site should be well drained, slightly elevated, and with a sunny exposure.

The plant is easily vegetatively propagated by softwood, hardwood, or root cuttings, or by division. Softwood cuttings, 4-6 inches long, taken during the summer will root under interrupted mist in 3 weeks or less. Hardwood cuttings, 6-8 inches long, can be rooted in the usual manner in cold frames in late fall and early winter; they also may be placed horizontally on the propagation media in a warm greenhouse in mid-winter to vegetate. When the young shoots that form abundantly along the hardwood cutting are several inches long, they are removed and handled as softwood cuttings. The same hardwood cutting will produce a sequence of shoots that can be periodically removed and rooted. Root cuttings, 4-6 inches long, inserted in the propagation media, root easily. Upon the digging of a specimen crapemyrtle, the roots which have been cut and not removed produce a dense circle of new plants in the same manner as root cuttings. The sucker shoots from the base of a plant can be removed to yield new plants. A specimen with multiple stems can be split apart to yield a limited number of multiplications.

The seeds of crapemyrtle germinate readily at a warm temperature. The germination of seeds results in a wide diversity of color and growth habit forms. Seedlings started early in the spring will often flower before frost or at least by the second year. Although seedlings may be produced in quantity, the entire range of resultant progeny will not be the same as the parents and will be very heterogeneous as to flower color, foliage, and growth habit. There is little merit to seed propagation except for breeding and selection purposes, as a salable plant of known ornamental merit can be produced more quickly and more efficiently by cuttings.

The best time to plant crapemyrtle is late spring and summer when the plant is actively growing. Dormant bare-rooted plants are often commercially

Fig. 6. Ballantine Blvd., Norfolk, Virginia, demonstrates the landscape use of crapemyrtle as a tree with handsome trunks that are scaled to streets with low overhead wires.

sold, but the survival or re-establishment is poorer than starting with transplanted balled and burlapped or container-grown plants. Quite frequently a dormant plant will not begin to grow actively until the second season after transplanting. In transplanting dormant plants it is beneficial to wrap their tops in plastic or cover with a plastic bag to increase temperature and hold moisture to force the plant into growth. The preferred transplanting time is when the new shoots are emerging in late spring and early summer; however, the plant can readily be transplanted when in full leaf with no curtailment of growth or flowering. Container-grown plants allow great latitude for summer planting.

Small plants frequently succumb to differing degrees of winter damage the first season or two. Old plants with woody trunks and branches can withstand more extreme winter conditions and are preferred for planting in the marginal hardiness zones. To further insure plant survival, a mulch over the roots and the wrapping of the trunk with straw, burlap, or bamboo matting are beneficial.

Crapemyrtle does not have fastidious soil require-

ments. The plant grows best in a reasonably good soil which is of a heavy loam to clay texture and with a pH of 5.0 - 6.5. In alkaline soils the foliage may show chlorosis and marginal leaf burn. The nutrient requirements are minimal. A light application of a 5-10-5 fertilizer in early spring may be beneficial to large specimen plants or those on extremely poor soils. With high fertility levels the plants produce much lush vegetative growth, flower less freely, and are subject to severe winter injury. In the more northern limits winter survival can be directly related to improper late season heavy fertilizer and water application.

During the spring through the flowering season, the plant benefits from periodic deep watering. If water is insufficient at flowering, the buds may fail to open and prematurely drop, and the leaves will yellow and drop. A mulch of sawdust, wood chips, pine bark, fiberglass, straw, black plastic, or other suitable material will reduce water losses and control weed growth under plants. As the season advances, the plant should not be excessively watered since this will induce vegetative growth and consequently greater winter injury of unhardened wood.

Crapemyrtle typically develops multiple stems, but early removal of all but the strongest branch will produce a single-stemmed plant. The multiple-stemmed plant is probably of greater ornamental merit and is more often encountered. If a large multiple-stemmed clump is required, several plants can be put in the same hole to quickly achieve the desired landscape effect.

Pruning practices followed will determine to a large degree the flowering response obtained. Basically, the pruning practices are: 1) standard or thinning practice; and 2) stump pruning.

The standard and more realistic pruning procedure is to remove old flower clusters and thin out most of the small twiggy growth. This is done when the plant is dormant and also during the growing season. Plants so pruned will have abundant flower trusses that are more proportional to the foliage and that are held erect for maximum display. In any pruning for open branching it is essential to remove enough center branches to allow for free air circulation through the plant and limit mildew infection. On very tall trees, removal of the old flower clusters may not be possible, and the pruning can best be restricted to thinning lower trunks and some heading back of a portion of the main branches. A slight amount of heading back each year will insure renewal of new wood and abundant flowering. All crapemyrtles will produce recurrent bloom if the inflorescences are not permitted to develop seed. Certain cultivars will set abundant seed after the first flowering, and unless these are removed, there will be no subsequent flowering during that season.

The stump pruning is the most drastic as it involves cutting the entire top back to the largest branches so as to leave only stumps 3-8 feet tall. New, vigorous, broom-type growth from the stump branches will produce the longest new shoots and the largest flower trusses, but fewer in number. The use of this type of pruning routinely results in a distorted type plant which never has an opportunity to develop the spectacular trunk. Likewise, the flower trusses are often massive and arch awkwardly. Stump pruning, cutting to ground level, is successfully used to maintain the dwarf types for bedding purposes. Stump pruning is done in late winter or early spring when the plant is dormant.

Part two of this comprehensive article will follow in another issue of the *Bulletin*. In it Dr. Egolf discusses disease and insect problems, development of new cultivars, species of crapemyrtle, superior cultivars of *L. indica*, and famous crapemyrtle gardens.

SUMMER COMES IN THE MORRIS ARBORETUM

H. L. Li

Fig. 1.
The pointed bracts of *Cornus kousa* sparkle against lush green foliage in June.

As spring passes into summer during the month of June, the Morris Arboretum continues its display of great floral beauty throughout the grounds. While the flowering season reaches its peak in May, June is still very floriferous, having the second highest number of kinds of plants in bloom of all the months of the year. As the summer approaches through June, the hours of sunlight lengthen and temperatures climb. Thereafter, fewer and fewer species come into flower and the flowering season gradually comes to its end in August.

To aid visitors in locating their favorite flowers or other interesting blooms, the following account, as a continuation of our Spring listing (Morris Arboretum Bulletin 22(1): 3-6, 1971), enumerates some of the common as well as lesser known species. Their blooming dates, as recorded at the Arboretum during the past ten years, fall in June, July, and August. These represent approximate beginnings of the flowering periods and an allowance of one to two weeks should be made due to possible climatic variations.

A number of the more notable flowering species for each of the months will be briefly mentioned. To assist in locating these plants on the grounds, an outline map of the Morris Arboretum is provided (Fig. 2). Approximate locations are indicated by corresponding letters in the text (capitals in parentheses).

June

Many of the May flowers may also last into the early or even later part of June, such as Azaleas (especially the native American species), lilac (*Syringa pekinensis*), Epaulette-tree (*Pterostyrax hispida*), Snowbell (*Styrax japonica*), Mountain-laurel (*Kalmia latifolia*), Mock-orange (*Philadelphus*), and Weigela. The more typical June flowers which usually start blooming within the month are listed below. Because of the large number of species in bloom, the list for the month is divided into three successive periods.

Among the more notable species flowering in June are certain magnolias, such as the Large-leaved Cucumber Tree (*Magnolia macrophylla*), Umbrella Magnolia (*M. tripetala*), and others, which can be seen among the Magnolia collection below the drive inside the Service Gate (A), as well as near the Log Cabin (B). Later in the month, the evergreen Bull Bay, (*M. grandiflora*) comes into bloom. This highly ornamen-

Fig. 2. Map showing locations of some summer-blooming flowers on the grounds of the Morris Arboretum. See text for explanation of letterings.

tal American tree is not reliably hardy in this area but a fairly large and quite floriferous specimen can be seen in front of the garage (C). Other varieties of *M. grandiflora* in the Arboretum vicinity begin blooming during the first week of June year after year.

Another notable group of trees is the stewartias, which begin blooming toward the latter part of the month and continue into July or even August. Their showy white, fringed petals are, like those of the Bull Bay, set off distinctly from their background of dark green foliage. Most of the *Stewartia* species (D) are located southwest of the Rose Garden.

June is the month of roses. The Rose Garden (E) of the Morris Arboretum is a collection of horticultural varieties rather than a species collection. New varieties developed each year are represented in the garden. The Rose Garden is currently under renovation, as many of the plants, being of considerable age and affected by crown galls and repeated winter injury, are in need of replacement. New beds have been prepared and we expect to have a reasonably good show this summer.

Early June

Actinidia chinensis	6/6
Cornus kousa	6/1 – 6/12
Deutzia parviflora	6/1 – 6/6
Ehretia thyrsiflora	6/6
Erica cinerea vars.	6/7
Erica tetralix vars.	6/7
Magnolia macrophylla	6/11 – 6/18
Magnolia tripetala	6/8
Philadelphus virginalis	6/1
Rhododendron minus	6/7
Spiraea bumalda	6/8 – 6/26
Spiraea billiardii	6/8
Stephanandra incisa	6/1
Syringa amurensis japonica	6/2
Vaccinium oldhamii	6/7 – 6/11
Viburnum dilatatum	6/7 – 7/10
Weigela decora	6/1 – 6/11

Mid-June

Calluna vulgaris vars.	6/7 – 7/7
Cotoneaster racemiflora	6/14

Cotoneaster salicifolia	6/14
Cytisus austriacus	6/15
Cytisus purpureus	6/15
Deutzia schneideriana	6/14
Elaeagnus angustifolia	6/16
Euonymus japonica	6/14
Gaultheria vulgaris vars.	6/14
Hydrangea macrophylla	6/25
Hydrangea quercifolia	6/10
Itea virginica	6/17
Ligustrum vulgare	6/15
Lyonia ligustrina	6/15
Pernettya mucronata	6/10 – 6/11
Rhododendron catawbiense	6/6
Robinia viscosa	6/13
Sambucus canadensis	6/10 – 6/26
Tripterygium regelii	6/10
Zenobia pulverulenta	6/4

Late June

Albizzia julibrissin	6/24 – 7/7
Catalpa bignonioides	6/12 – 6/25
Cotinus coggygria	6/21 – 6/26
Decumeria barbara	6/25 – 6/29
Diervilla lonicera	6/26
Lonicera henryi	6/18
Magnolia grandiflora	6/9 – 6/25
Rhododendron arborescens	6/10 – 6/28
Sorbaria sorbifolia	6/18 – 7/16
Sorbaria koreana	6/18 – 7/5
Stewartia malacodendron	6/18 – 6/25
Stewartia monadelpha	6/26
Stewartia ovata	6/18 – 7/12
Stewartia pseudocamellia	6/26

July

Although fewer species come into bloom in July, there are still some interesting flowering trees and shrubs during this month, such as the Sorrel-tree (*Oxydendrum arboreum*) (F), the bee-bee trees (*Evodia* spp.) (G), the Pagoda Tree (*Sophora japonica*) (H), and the Golden Rain Tree (*Koelreuteria paniculata*) (I). Among the notable shrubs are the floriferous Tamarisk (*Tamarix*) (J), *Sorbaria* (K), and butterfly bushes (*Buddleia* spp.) (L). The buddleias begin to flower in the late part of the month and often extend into August. The Dwarf Buckeye (*Aesculus parviflora*), which can be found at several localities (M), is a low bushy relative of the buckeyes and horse chestnuts. It bears long, erect panicles of white flowers. Because it usually starts blooming quite regularly in the early part of the month, around July 4, it is sometimes referred to as the Independence Tree.

Fig. 3. This Bull Bay, *Magnolia grandiflora*, remains in full leaf even through the winter in its sheltered place at the Arboretum.

Early July

Abelia grandiflora	6/29 – 7/24
Aesculus parviflora	6/29 – 7/12
Hibiscus syriacus	7/1 – 8/25
Kalmia angustifolia	7/11
Koelreuteria paniculata	7/10 – 7/11
Nandina domestica	7/10 – 7/11
Oxydendrum arboreum	7/1 – 7/15
Rhus chinensis	7/12 – 7/16
Rhus sylvestris	7/12
Zizyphus jujuba	7/1 – 7/16

Late July

Buddleia davidii	7/26 – 8/7
Buddleia stenostachya	7/17
Campsis radicans	7/24
Clethra alternifolia	7/20 – 8/13
Cyrilla racemiflora	7/27
Elliotia racemosa	7/16 – 7/30
Evodia daniellii	7/28
Evodia hupehensis	7/16 – 7/17
Hovenia dulcis	6/26 – 7/18

Hydrangea paniculata	7/15 – 8/5
Hypericum patulum	7/12 – 7/20
Maackia amurensis	7/19
Rhododendron prunifolium	7/17
Sophora japonica	7/5 – 8/7
Spiraea latifolia	7/15
Tamarix pentandra	7/16 – 7/26
Vitex agnus-castus	7/26 – 8/5

August

By the month of August, along with the hot climate, fewer and fewer plants come into flower. Although the flowering season comes to its end toward the latter part of the month, there are still some highly ornamental plants that start flowering in this late season. The delicate but very showy flowers of the crapemyrtle (*Lagerstroemia*) are especially noteworthy (N). One of the most famous ones that originated in eastern North America, the Franklin Tree (*Franklinia alatamaha*), also blooms in this month (O). This is a small tree, a member of the Tea family, with beautiful large white flowers somewhat resembling camellias and stewartias. The tree is famous not only because its name commemorates Benjamin Franklin, but also because of its rareness. It now appears only in cultivation as it has disappeared from its natural habitat in the mountains of Georgia where it was discovered in the late 18th century.

Fig. 4. The graceful, June-blooming *Buddleia alternifolia* is earlier than other members of the genus.

Aralia spinosa	8/3 – 8/29
Clematis spp.	8/12 – 8/26
Clerodendron trichotomum	8/22 – 9/22
Euonymus kiautschovica	8/8 – 8/24
Franklinia alatamaha	8/9 – 8/16
Lagerstroemia indica	8/9 – 9/9
Leiophyllum buxifolium	8/1
Lyonia mariana	8/28
Ptelea trifoliata	8/13
Syringa microphylla	8/12

About Our Authors

Dr. Ronald R. Egolf, Ph.D., Cornell (Plant Breeding) is Research Horticulturist at the National Arboretum in Washington, D. C. As an undergraduate (Pennsylvania State University) and graduate student he was the recipient of numerous scholarships. Before going to the National Arboretum in 1958, he was a Fulbright Scholar in London. Several important genera of woody ornamental plants have received his research attention, including *Viburnum* and *Pyracantha.* The second part of his comprehensive article on *Lagerstroemia* will appear soon.

Mrs. Leola L. Willaman is a prize-winning amateur horticulturist who has been an Associate of the Aboretum for many years. Her daughter, Dorothy W. Haas, collaborated with her in the preparation of their effective presentation of microclimates in the garden. For information about a third member of the family, turn to "Associates News."

MICROCLIMATES IN YOUR GARDEN

Leola L. Willaman and Dorothy W. Haas

If the climate of a country depended solely upon its distance from the equator, arid north Africa and wet southeast Asia would have the same weather. Balmy southern Ireland would resemble frozen northwest Canada. However, mountain ranges, ocean currents, prevailing winds, level land allowing free airflow affect the climate of continents. In miniature ways, plantings, exposure, prevailing winds and open spaces can all affect the weather in spots around the home grounds. Thus there are "microclimates" in your garden.

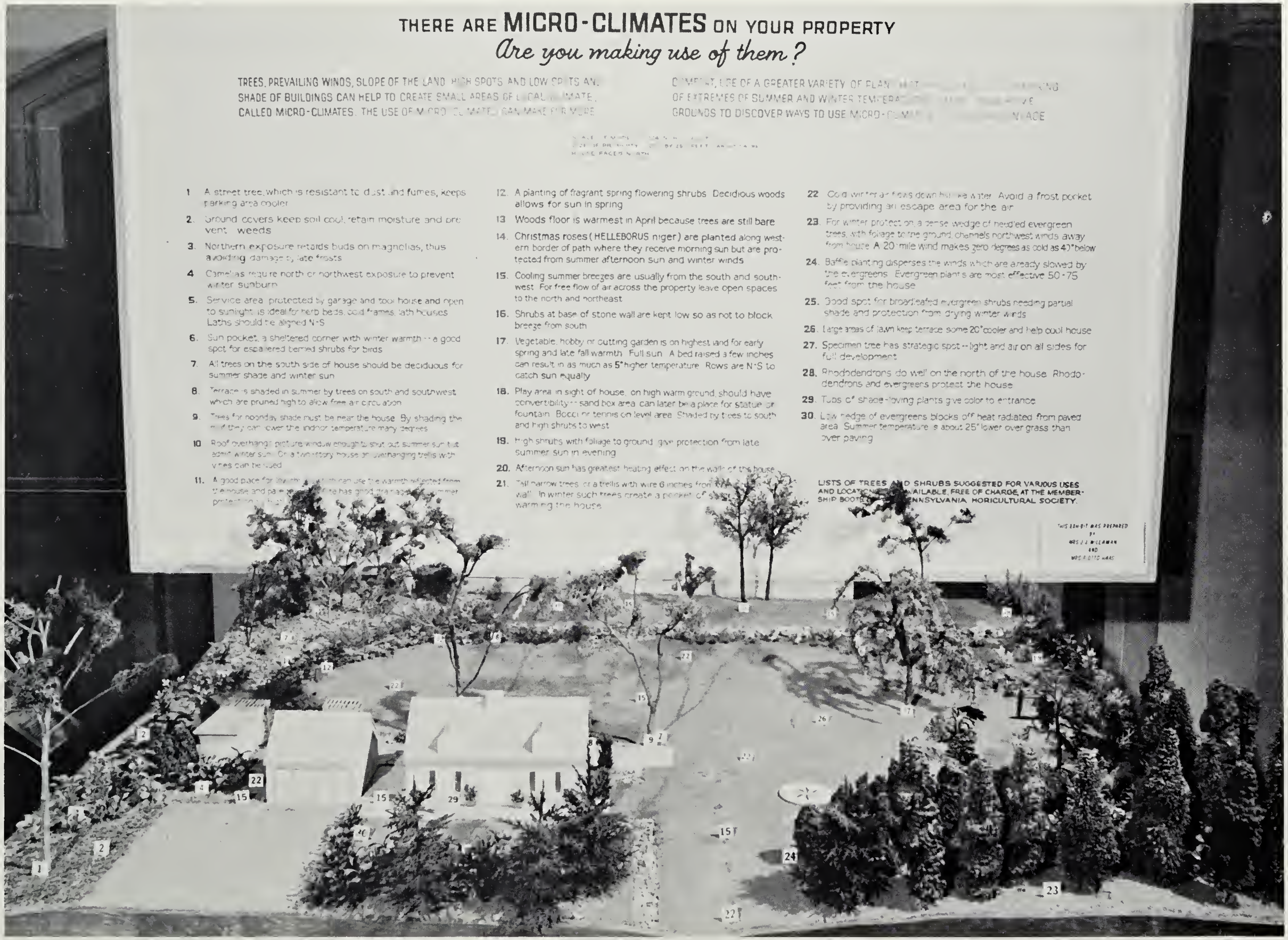
There is considerable scientific literature on this subject, also articles interpreting microclimates in relation to home grounds. From this material we gathered information which the average home owner can use. We constructed a model, with husbandly help, which would demonstrate as many aspects of microclimate as would be significant for home owners. The house faces north and the land slopes gently downward toward the north. The area represented is 150 by 200 feet, with a scale of one-fourth inch to one foot. The model was displayed at a Philadelphia Spring Flower Show, and was subsequently given to the Pennsylvania Horticultural Society.[1]

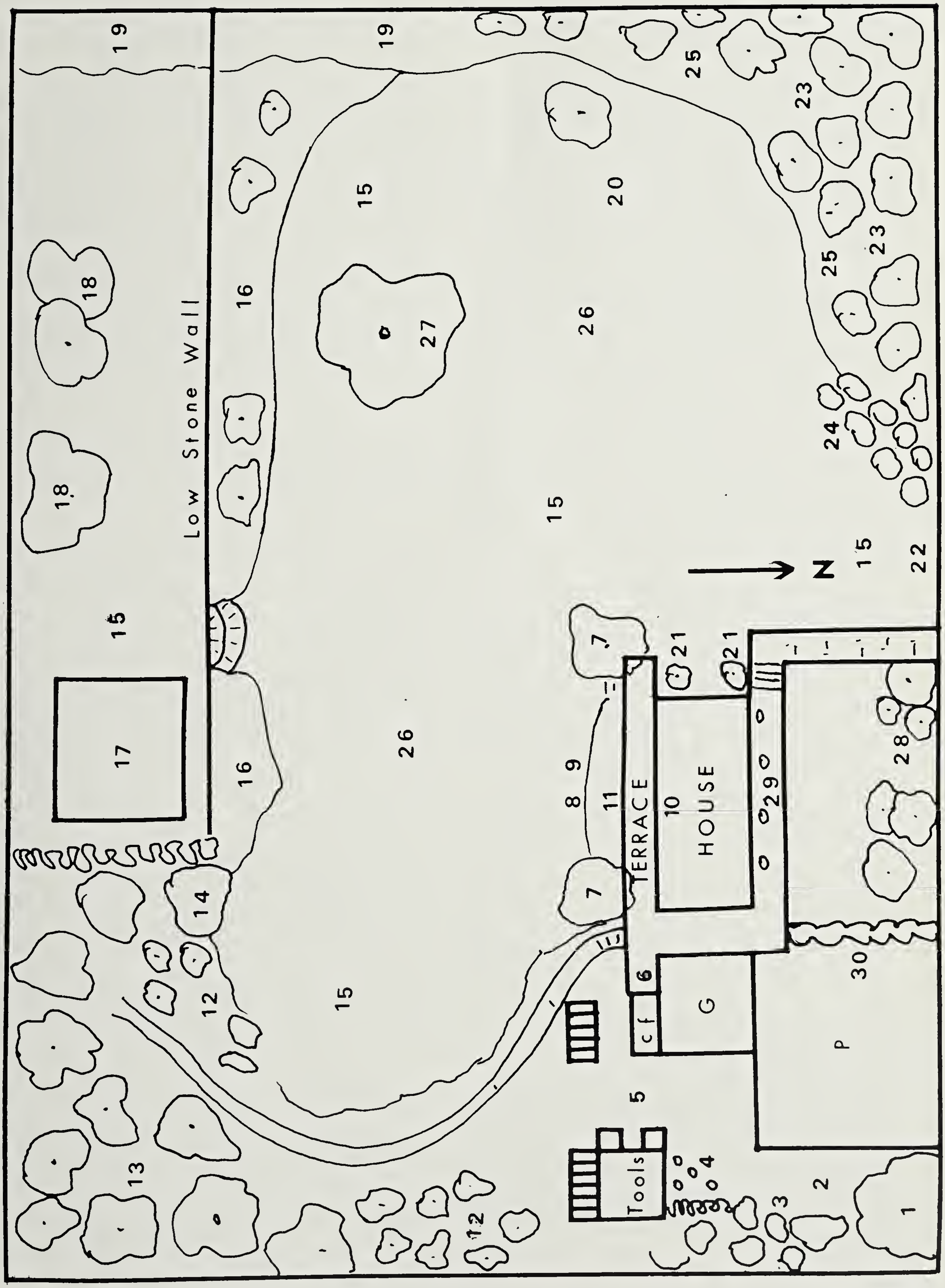
On the next page is a photograph of the model and its accompanying backboard of information. Next to it is a map showing the location of areas of interest. The numbers on the model and on the map refer to individual manipulations, or utilizations of microclimates. These items were explained on the backboard of the model and follow in the same order here.

A garden tour is now in order, starting at number 1 in the lower left corner and continuing to 30, where you will be back at your car in the parking area (P).

1. A street tree, resistant to dust and fumes, keeps the parking area cooler.
2. Ground covers keep soil cool, retain moisture, and help to prevent weeds.
3. The northern exposure retards the buds on magnolias in the spring, thus avoiding frost damage.
4. Camellias require a north or northwest exposure to prevent winter sunburn.
5. Service area, protected by garage (G) and tool house, is open to sunlight and is an ideal spot for herb beds, cold frames (cf), and lath houses. Laths should be aligned north-south.
6. Sun pocket behind the garage, is a sheltered place with winter warmth—a good spot for espaliered, berried shrubs for birds (and for early spring and late fall coffee breaks for people).
7. All trees on the south side of the house should be deciduous, for summer shade and winter sun.
8. Terrace is shaded in summer by trees on the south and southwest, which are pruned high to allow free air circulation.
9. Trees for noonday shade must be as near the house as practicable for shade on the roof, which can lower the house temperature several degrees in summer.
10. Roof of this one-story house overhangs the picture window enough to shut out summer sun but admit winter sun. On a two-story house use an overhanging trellis with vines.
11. This is a good place for low shrubs which can use the warmth reflected from the house and paved terrace. Site has good drainage and summer protection by high shade.
12. A planting of fragrant, spring-flowering shrubs along the path to the woods. Deciduous woods to the south of these shrubs allows for sun in early spring.
13. Woods' floor is warmest in April because the trees are still bare; the natural place for many spring wild flowers.
14. Red-twigged dogwood—a good spot for winter color enjoyable from the house, against evergreens.
15. Cooling summer breezes are usually from the south and southwest. For free flow of air across the property leave open spaces to the north and northeast.
16. Shrubs at base of stone retaining wall are kept low to avoid blocking the breeze from the south.
17. Vegetable or cutting garden is on highest land for the advantage of early spring and late fall warmth. A bed raised a few inches can be as many as five degrees higher in average temperature. Rows are north-south to catch the sun equally. This is the place for your hobby garden. Do you like roses, gladiolas, lilies?
18. Play area for children, in sight of house, on warm high ground, can later be a place for statue or fountain, bocci or tennis, shaded by high trees to the south and shrubs to the west.
19. High shrubs, with foliage to the ground, give protection from late afternoon sun.
20. Afternoon sun has the greatest heating effect on the house in summer. For shade, use trees with low branches.

[1] An abbreviated version of this work appeared in "Flower and Garden," October, 1970.


THERE ARE MICRO-CLIMATES ON YOUR PROPERTY
Are you making use of them?
TREES, PREVAILING WINDS, SLOPE OF THE LAND, HIGH SPOTS AND LOW SPOTS AND
SHADE OF BUILDINGS CAN HELP TO CREATE SMALL AREAS OF LOCAL CLIMATE,
CALLED MICRO-CLIMATES. THE USE OF MICRO-CLIMATES CAN MAKE FOR MORE
OF EXTREMES OF SUMMER AND WINTER TEMPERATURE
GROUNDS TO DISCOVER WAYS TO USE MICRO-CLIMATES
1 A street tree, which is resistant to dust and fumes, keeps parking area cooler
2. Ground covers keep soil cool, retain moisture and prevent weeds
3. Northern exposure retards buds on magnolias, thus avoiding damage by late frosts
4 Camelias require north or northwest exposure to prevent winter sunburn
5. Service area protected by garage and tool house and open to sunlight is ideal for herb beds, cold frames, lath houses. Laths should be aligned N-S
6. Sun pocket, a sheltered corner with winter warmth -- a good spot for espaliered berried shrubs for birds
7. All trees on the south side of house should be deciduous for summer shade and winter sun
8. Terrace is shaded in summer by trees on south and southwest which are pruned high to allow free air circulation
9. Trees for noonday shade must be near the house. By shading the roof they can lower the indoor temperature many degrees
10 Roof overhang: picture window enough to shut out summer sun but admit winter sun. On a two-story house an overhanging trellis with vines can be used
11. A good place for
12. A planting of fragrant spring flowering shrubs. Deciduous woods allows for sun in spring
13 Woods floor is warmest in April because trees are still bare
14. Christmas roses (HELLEBORUS niger) are planted along western border of path where they receive morning sun but are protected from summer afternoon sun and winter winds
15. Cooling summer breezes are usually from the south and southwest. For free flow of air across the property leave open spaces to the north and northeast
16. Shrubs at base of stone wall are kept low so as not to block breeze from south
17. Vegetable, hobby or cutting garden is on highest land for early spring and late fall warmth. Full sun. A bed raised a few inches can result in as much as 5° higher temperature. Rows are N-S to catch sun equally
18. Play area in sight of house, on high warm ground, should have convertibility -- sand box area can later be a place for statue or fountain. Bocci or tennis on level area. Shaded by trees to south and high shrubs to west
19. High shrubs with foliage to ground give protection from late summer sun in evening
20. Afternoon sun has greatest heating effect on the walls of the house
21. Tall narrow trees or a trellis with wire 6 inches from wall. In winter such trees create a pocket of warming the house
22 Cold winter air flows down hill like water. Avoid a frost pocket by providing an escape area for the air
23. For winter protection a dense wedge of needled evergreen trees, with foliage to the ground, channels northwest winds away from house. A 20 mile wind makes zero degrees as cold as 40° below
24. Baffle planting disperses the winds which are already slowed by the evergreens. Evergreen plants are most effective 50-75 feet from the house
25. Good spot for broadleafed evergreen shrubs needing partial shade and protection from drying winter winds
26. Large areas of lawn keep terrace some 20° cooler and help cool house
27. Specimen tree has strategic spot -- light and air on all sides for full development
28. Rhododendrons do well on the north of the house. Rhododendrons and evergreens protect the house
29. Tubs of shade-loving plants give color to entrance
30. Low hedge of evergreens blocks off heat radiated from paved area. Summer temperature is about 25° lower over grass than over paving
LISTS OF TREES AND SHRUBS SUGGESTED FOR VARIOUS USES AND LOCATIONS AVAILABLE FREE OF CHARGE AT THE MEMBERSHIP BOOTH PENNSYLVANIA HORICULTURAL SOCIETY.


Low Stone Wall
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21. Tall, narrow trees, or a trellis six inches from the wall will shade the wall in summer. In winter such plants create a pocket of stagnant air, insulating the house.
22. Cold winter air flows downhill like water. Avoid a frost pocket by providing an escape for the air out of the property.
23. For winter protection, a dense wedge of evergreen trees, with foliage to the ground, channels northwest winds away from the house. A 20-mile wind makes zero degrees as cold as 40 below. Evergreen trees are most effective 50-75 feet from the house.
24. Baffle planting disperses winds which are already slowed by the evergreens.
25. This is a good spot for broad-leaf evergreen shrubs needing partial shade and protection from drying winter winds.
26. Large areas of lawn keep the terrace some 20 degrees cooler, and the house also cooler. Grass blades shade the soil enough to do this, but grass cut too short loses this cooling effect.
27. This specimen tree has a strategic spot—light and air on all sides for full development. Notice that this and No. 20 are the only trees not in a border kept mulched for ease of mowing.
28. Rhododendrons do well on the north of the house, where they do not get the drying winter sun. Here they provide year around privacy from the street.
29. Tubs of shade-loving plants give color to the entrance.
30. A low hedge of evergreens blocks off heat radiated from paved area. Summer temperature is about 25 degrees lower over grass than over pavement.

You are now back at the starting point. We hope you have enjoyed your tour and are more conscious of the possible microclimates in your own property.

Here is a list of suggested shrubs and trees for various microclimatic situations.

TREES WHICH ENDURE STREET CONDITIONS: *Quercus rubra* (Red Oak), *Ginkgo biloba* (Maidenhair Tree).

DECIDUOUS TREES FOR HIGH SHADE: Zelkova, Moraine Locust, *Sophora* (Scholar Tree).

DECIDUOUS TREES FOR SHADE TO GROUND LEVEL: *Cornus florida* (Dogwood), *Malus floribunda* (Flowering Crab), *Prunus subhirtella* (Higan Cherry).

NEEDLED EVERGREENS WITH BRANCHES TO GROUND: *Picea engelmannii* (Engelmann Spruce), *Pinus strobus* (White Pine), *Thuja occidentalis robusta* (Arborvitae).

SPECIMEN TREE: *Acer palmatum* (Japanese Maple), *Prunus fruticosa pendula* (Weeping Cherry), *Tsuga canadensis pendula* (Sargent's Weeping Hemlock).

TALL SHRUBS WITH FOLIAGE TO THE GROUND: *Lonicera morrowii* (Japanese Bush Honeysuckle), *Philadelphus* (Mock Orange), *Cotinus coggygria* (Smoke Bush).

FRAGRANT SHRUBS FOR SPRING BLOOM: *Ribes odorata* (Clove Currant), *Elaeagnus angustifolia* (Russian Olive), *Viburnum bodnantense*, *Lonicera fragrantissima* (Fragrant Honeysuckle).

GROUND PLANTING IN WOODS: *Mertensia virginica* (Virginia Bluebell), *Arisaema triphyllum* (Jack-in-the-Pulpit), *Aquilegia canadensis* (Native Columbine).

LOW-GROWING SHRUBS: *Hypericum moserianum* (Gold Flower), *Deutzia gracilis* (Slender Deutzia), *Corylopsis pauciflora* (Japanese Flowering Hazel), *Pinus mugho* (Mugho Pine).

SHRUBS FOR WINTER COLOR: *Cornus stolonifera lutea* (Yellow-twig Dogwood), *Cornus sibirica* (Coral-twig Dogwood), *Biota orientalis deccusata* (Oriental Arborvitae, mauve), *Chamaecyparis pisifera aurea* (Golden Sawara Cypress).

SHRUBS BY TERRACE NEEDING HIGH SHADE AND GOOD DRAINAGE: Azalea, Polyantha Roses, *Cotoneaster horizontalis* (Rock Spray) with spring bulbs.

VINES FOR TRELLIS OVER PICTURE WINDOW: Wisteria and Clematis.

GROUND COVERS: *Vinca minor* (Periwinkle), Pachysandra, *Ajuga* (Bugle weed), *Jasminum nudiflorum*, (Winter Jasmine), Ivy, Wood chips, Fallen leaves, *Juniperus horizontalis glauca*.

SHRUBS AMONG EVERGREENS NEEDING SHADE AND WINTER PROTECTION: *Ilex* (Holly), *Leucothoe catesbaei* (Leucothoe), *Kalmia latifolia* (Mountain Laurel), *Mahonia aquifolium* (Mahonia).

USE OF LATH HOUSES: Summering house plants, bonsai, hanging baskets.

SHADE-LOVING PLANTS IN TERRACE TUBS: Tuberous Begonia, Ivy, Ferns.

HARDY CAMELLIAS: 'Berenice Boddy', 'Marjorie Magnificent', 'Ville de Nantes', 'T.K. Variegated'.

SHRUBS WHICH BLOOM IN SHADE OF WOODS: *Kerria japonica*, *Aesculus parviflora* (Bottle Brush Buckeye), *Ribes aureum* (Golden Currant).

SHRUBS BETWEEN PARKING AREA AND FRONT LAWN: *Ilex microphylla*, (Small-leaved Holly), *Thuja occidentalis compacta* (Compact Arborvitae), *Taxus cuspidata densa* (Dwarf Japanese Yew).

HOBBY GARDEN: Gladioli, Roses, Iris, Fruit and Vegetables.

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Associate's News

April Walk and Talk

The first of the season's special tours for Associates was led by Mr. Heeps on April 17. Features of the day were the early magnolias, *M. stellata* and *M. soulangiana* in great array, including the incredible *M. soulangiana* 'Alexandrina' on the northwest slope; the best showing ever of the hardy camellias by the fernery; the fernery itself where giant pink fronds of *Blechnum brasiliense* were unrolling into the light; the early rhododendrons, *R. degronianum*, pink and dwarf in the heather garden, and *R. mucronulatum*; the little blue *Anemone blanda* in the heather garden; the cherries *Prunus yedoensis* and the gentle *P. subhirtella pendula*; fragrant *Erysimum odoratum* beside the greenhouse; and the new additions to ground level Springtime at the Arboretum, troops of *Primula officinalis* and *P. vulgaris.*

Spring Short Courses

May 6th was the last meeting day for the Spring Session of the botanical short courses. After the last session, the students and instructors from the four different classes gathered as Arboretum guests for luncheon and a talk on "Ecuadorian Landscapes" by Dr. Allison. The Fall series is now being planned, so Associates are encouraged to let their wishes be known soon.

New Garden Club Memberships at the Arboretum

An interesting form of Associate Membership is now being planned specifically for Garden Clubs in the area. It is anticipated that the Arboretum will provide the meeting place once a year for each member club and assist with club projects.

Barnes Lecture

The 10th annual Laura L. Barnes Lecture was presented on April 8 by Dr. Russell J. Seibert, Director of Longwood Gardens. An essay based on his worthwhile address, "The Effects of Air Pollution on Ornamental Plants," will appear in the next issue of the *Bulletin.*

Double Bequest

The late Mr. Richard B. Chillas, long time Associate and member of the Morris Arboretum Advisory Council, made a gift of his unusual collection of Kodachrome slides of plants. There are approximately 3500 transparencies (3467 of them named), now systematically arranged according to family and designated "The Chillas Collection."

Mr. Chillas' bequest also included a share in his residual estate.

Gift of a Library

Dr. Edgar T. Wherry, Professor Emeritus, has given the Arboretum the greater part of his own botanical library comprising 170 items, mostly floristic works. Many of them were not represented in the Arboretum library until now; thus Dr. Wherry's generosity will greatly strengthen our holdings in floristic botany.

Short Course Alumna

An Associate of the Arboretum, Mrs. Ruth McVaugh Allen, enrolled in a short course on the fungi several years ago, little thinking that she would become part of a team now receiving international acclaim. She became so interested in the slime molds (Myxomycetes) that she began cultivating them for serious study, and illustrated her independent endeavors with colored drawings. These were brought to the attention of Professors G. W. Martin and C. J. Alexopoulos. She was invited to illustrate their recently published world monograph on that class of fungi. Mrs. Allen also discovered a new species that is described in the monograph. The entire work was underwritten by grants from the National Science Foundation.

Recent Publication

Dr. J. J. Willaman, long an Associate, became a collaborator and Research Associate of Dr. Li in early 1967. Their work was supported by the National Institutes of Health, and recently culminated in the publication, "Alkaloid-bearing plants and their contained alkaloids, 1956–1968," which is a supplement to volume 33 for 1970 of *Lloydia*, the Journal of Natural Products.

A New Morris Arboretum Monograph

Li, H. L. "Floristic relationships between eastern Asia and eastern North America." This work was originally published as a part of the Transactions of The American Philosophical Society. Because of extensive demands, it has been out of print for some time. Now it is again available, having been augmented by a foreword bringing the literature up to date, as a Monograph of the Morris Arboretum.

Butterflies from the Arboretum

Arthur M. Shapiro, then a teenage Associate, wrote "The Butterflies of the Morris Arboretum" (*Morris Arb. Bulletin* 14: 8-14, 32-36, 67-69, 1963; 17: 14, 1966). We have learned recently that a specimen he collected here has since been designated neotype of the taxon *Lethe eurydice* Johansson. It is now in the US National Museum collection along with another Arboretum example of the species. Shapiro, recent Ph.D. from Cornell, is now Assistant Professor of Biology, Richmond College of the City University of New York, Staten Island, N. Y.

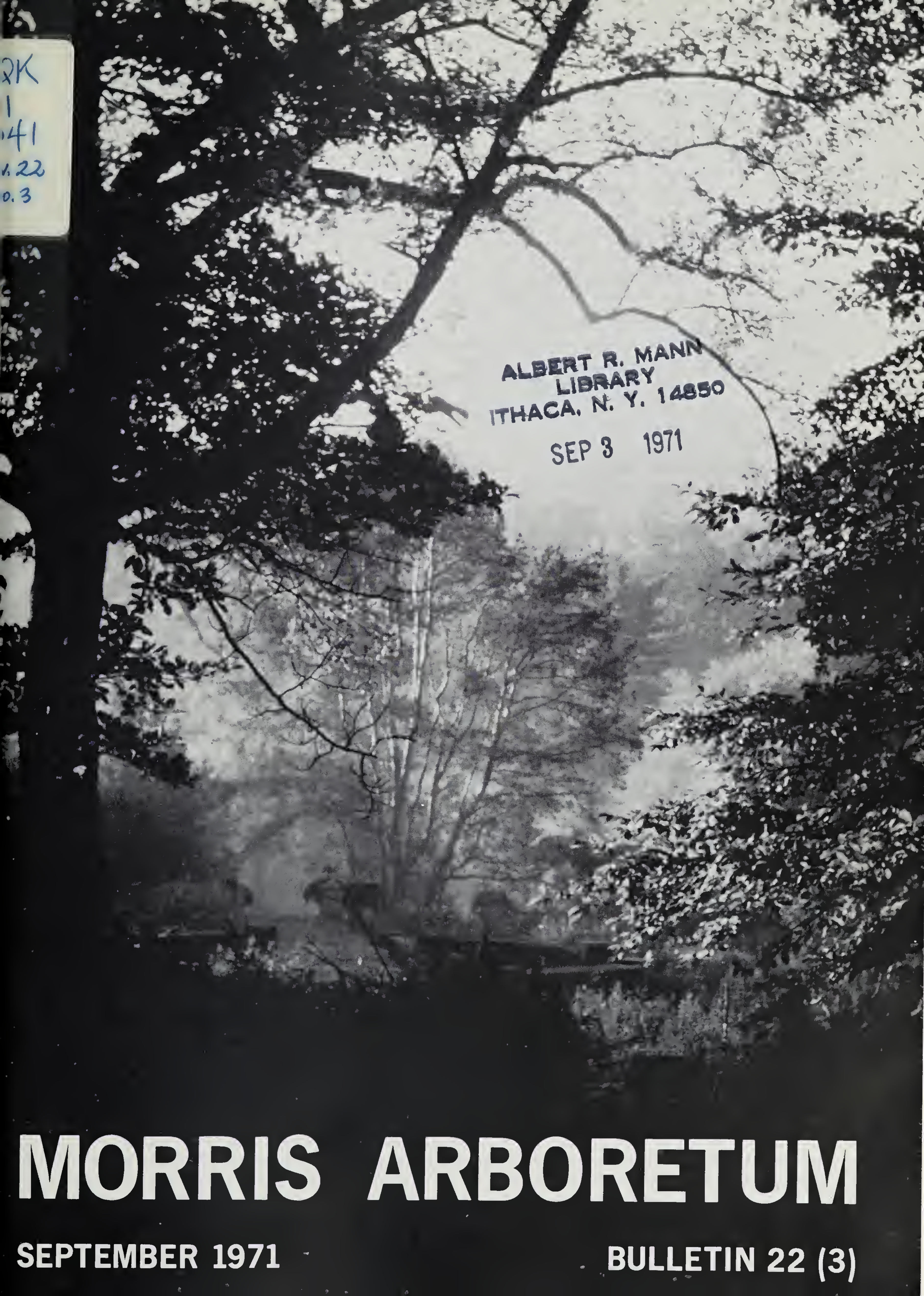
Good News from Former Pathologist

Dr. Spencer Davis, former Plant Pathologist at the Morris Arboretum, has recently been evaluating some of the new "systemic" fungicides. Such a compound has the property of entering a plant and there remaining in an active, protective form for a significant period. Now there is hope that such diseases as fungal wilts and cankers of woody plants might be controlled. Early laboratory tests by Spencer and Dr. J. L. Peterson indicate that benomyl is active in tree wound paint against four dangerous fungi, including the one that causes Cankerstain of London Plane.

Several years ago the present Pathologist, Patricia Allison, found that Petal Blight of Azalea and Rhododendron was in the Philadelphia area. Dr. Davis and his colleague demonstrated that benomyl was excellent for its control in trials during 1970 in New Jersey.

Associate Outwits Deer

David Earnshaw is fond of apples and pears, and so planted choice grafted varieties in his garden by his summer home away in the Wallenpaupack area of Pennsylvania. Deer also are fond of apple and pear trees. They came from miles around to browse the twigs and bark. They have been fooled. Our Associate found some less succulent apple seedlings growing in his woodland that the deer have ignored. To these, where they stand, at heights above the reach of the deer, he has successfully budded his select types of fruit trees.



MORRIS ARBORETUM

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

TYPES OF MEMBERSHIP

Contributing	$10.00 a year	Supporting	$25.00 a year
Family	$15.00 a year	Sponsoring	$100.00 a year
Donor	$500.00		

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COVER: The slanting light of Autumn illuminates bright color patches and reveals new vistas. Photo by William Wright, Morris Arboretum gardener.

THIS ARTICLE IS BASED ON THE NINTH ANNUAL LECTURE HONORING DR. LAURA L. BARNES THAT WAS PRESENTED ON APRIL 8, 1971

THE EFFECTS OF AIR POLLUTION ON ORNAMENTAL PLANTS

Russell J. Seibert, Director
Longwood Gardens

Green open space is a most precious heritage—that and the right to breathe clean, fresh air.

Slowly but surely, urban man has become increasingly isolated from a natural setting around his home. This trend has been underway at least since Nineveh and Assyrian times. Much later, Ephesus, which has been credited for the first multi-family dwellings, and many other intriguing ancient cities around the world lost their close association with nature before they met complete collapse.

If man is fortunate enough today, he may still live on a property which separates the home from the street with some space and green plants; or he may live in a glass tower which looks out on a park or toward the distant tree-covered hills. Why do YOU think that the two-acre suburban plot has become the status symbol of middle-income America?

Unfortunately, urban man is increasingly condensed into smaller and smaller space where trees and grass and shrubs are evicted because they seemingly do not pay rent! Fortunately, the dwellers of some of the nation's most crowded cities may benefit from the forethought and legacies of a few philanthropists. They may wander, enveloped in natural beauty, breathing natural perfume, enjoying natural green textures through the plots, large or small that are the nation's botanical gardens.

Man evolved within a natural forest and wilderness setting. His first livelihood came from the forest which he has progressively destroyed. Then, throughout his agricultural era, man never ceased raping his soil. As a city dweller, his environment has become sterile of nearly all of nature except other humans, cockroaches, bedbugs and rats, where plants—even house plants—no longer exist as a part of man's last thread of attachment to the green world. He has lost the will to keep his surroundings clean and beautiful. He is a litter bug. He no longer teaches human decency to his children. Is this a direct toxic effect of air pollution on the mind? Or is there some sort of inverse relationship between human demoralization and man's association with plants? Not that everyone who lives in the most crowded portions of cities is a criminal any more than those of us who live and work in gardens are angels. But there is some sort of correlation. It often has been said that, "Gardeners are friendly people." It is true that horticultural and botanical groups enjoy the best of reputations for human decency with the inn and hotel keepers who host these organizations during their conventions. To be sure, plantsmen do not spend much money, but then neither do they cause trouble and damage to property.

The point is this: we cannot continue to ruin our green space. Indeed, we have already overstepped the bounds. Even the legacies of gardens, left to us by magnanimous citizens, are suffering. Urban renewal must include EXPANSION of parks, street plantings, gardens, NOT contraction, for these are the "lungs of the metropolis."

Let one trained at a metropolitan botanic garden, then, for twenty years, director of botanic gardens in or near metropolitan areas, reveal how concerned a botanist can be about horticulture and the urban crisis. I have become familiar with city plantings in three of the most air-polluted metropolitan areas of the nation—St. Louis, Los Angeles, and Philadelphia. In the Los Angeles area, I arrived at a time when air pollution had already started causing injury to street trees. It had already wiped out spinach as an agricultural industry in the county. It was adversely affecting the citrus industry in Southern California.

Apart from financially justifying the need for developing a metropolitan arboretum and botanical garden system in the area, my most serious problem was trying to keep the thousands of new plants alive from which the arboretum and botanical garden were to build themselves. Hundreds of specimens failed to survive because of the smog. But, among the other thousands that did survive were some resistant individuals such as a reclinate date palm and the eucalyptus. Therein I learned a great lesson. There are plant species and individuals existent that do survive in man-made atmospheric and environmental filth! In spite of the demise of certain forests in the mountains to the east of Los Angeles caused by drifting smog,

the Los Angeles valley today has amassed through trial and error one of the greatest collections of exotic air-pollution-tolerant plants in the world. Those plants are grown under the most adverse conditions of polluted air and irrigation. This, to a plantsman, is an exciting fact and one which may be used to great advantage in logical plans to increase the quality and extent of green acreage.

We have learned, too, that certain plants are better sensors of air pollution than are most instruments. The most susceptible plants express pollution toxicity in a variety of ways that can be seen by anyone with normal vision. You and I can learn to recognize the symptoms on our plants. At Longwood Gardens, for instance, starting in early July, we see ozone symptoms on our dogwood–premature fall color!

To help understand what different kinds of air pollution do to injure plants, one may refer to the "Air Pollution Monograph" in which are examples of fluoride injury on grape, apricot, Dutch iris and loquat. Gaseous fluorides are toxic to some plants in as low as 0.1 to 0.5 parts to a billion parts of air (ppb). Fluorides may accumulate in excess of 30 to 40 parts per million (ppm) in the leaves. If this happens in forage crops, the poison can then cause fluorosis in animals, as happened in central Florida. Different plants show an enormous range of tolerance. Edge and tip burns or lesions frequently extend down the leaf blade. Other sensitive plants are shown in "Recognition of Air Pollution Injury to Vegetation, A Pictorial Atlas."

Usually, suspect fluoride sources include aluminum reduction, the smelting of iron and non-ferrous ores, ceramics firing, phosphate reduction, and petroleum refineries producing high test gasoline. The white flowered gladiolus 'Snow Princess' has been a favorite susceptible indicator for fluoride injury. On the other hand, lilac, rose, chrysanthemum, marigold, camellia, and rhododendron are among the genera rather resistant to fluoride injury.

Sulfur dioxide, next to smoke, is one of the oldest recognized air pollutants and has been associated with soft coal smoke for centuries. Those of us old enough remember its effects in St. Louis and Pittsburgh in the 1920's and 1930's. The effects of SO_2 on alfalfa, castor bean, pinto bean and cotton are highly damaging. There will be on sensitive oaks, extensive areas of leaf tissue collapse and desiccation, leaving a pattern of interveinal and marginal acute injury when the concentrations exceed 1.25 ppm for more than one hour. Some plants seem to *utilize* SO_2. Indeed, this is one of the ways in which plants today obtain their necessary amount of sulfur for growth. However, too much is detrimental to any plant. Here again, there is

Fig. 1. Premature reddening and stippling of *Cornus florida* from photochemical oxidants at Longwood Gardens.

a wide range of tolerance between different genera and species. Gladiolus, canna, rose, arbor vitae and privet are considered among the fairly resistant plants.

Photochemical smog results from reactions between oxides of nitrogen and organic vapors, hydrocarbons, in the presence of sunlight. Photochemical smog is among the most serious of our phytotoxicants or plant poisons, not only in Los Angeles, but in and around every metropolitan area of the world today. It is the major air pollution problem within the Delaware Valley. Typical "silvering" on the lower surface of the leaves occurs on Swiss chard and spinach. Necrotic banding results on pine needles, wild oats, and other grasses such as annual blue and crab grass, where multiple exposures of smog affect the growing blade. Usually, orchids are rather resistant to smog, but if ethylene is present, then "dry sepal" results on Cattleya flowers. Carnation flowers are injured. Acacia, Bermuda grass, pansy, rose, stock, lobelia, and dahlia are all quite resistant to photochemical smog. Usually, less than 0.4 ppm for an hour or two will cause visible effects on susceptible plants. Among the phytotoxic elements and compounds in photochemical smog are ozone and "PAN" (peroxyacetyl nitrate).

Pinto beans, petunia, citrus, avocado, and grape are all very susceptible to ozone. One of the classical indicator plants for showing the presence of ozone is Bell W3 tobacco. Symptoms appear within an hour.

PAN damage is illustrated in "Identification of Air Pollution Damage to Agricultural Crops." In concentrations of 0.05 ppm in about four hours PAN will

Fig. 2. Air pollution damage to *Rhododendron schlippenbachii*. Fluoride is suspected.

Fig. 3. Leaves of petunia 'Snowstorm'. Bleaching occurs on developing leaves exposed to toxic concentrations of ozone.

produce lesions on susceptible white petunia cultivars. There is silvering and bronzing of Romaine lettuce and Swiss chard on the lower surface of the leaves.

How have we learned what the specific symptoms are that specific poisons cause? Photochemical smog may be synthesized in plastic greenhouses by irradiating auto exhaust with sunlight. Arrays of plants in special chambers may be exposed to this or to measured concentrations of specific air pollutants or to naturally polluted air drawn in from outside. At the same time, activated-carbon-filtered air from which the pollutants have been removed is used on duplicate sets of control plants in another chamber. The result is to arrive at very precise differences in rate of growth and in injury due to the effects of each pollutant or combination of pollutants. These are the laboratory means which give weight to such headlines as "Flower producers lost millions of dollars from polluted air" (Florist and Nursery Exchange, Jan. 16, 1968). By 1956, smog was annually causing $5,000,000 worth of damage to food crops in the Los Angeles Valley alone. This was a ten-fold jump in about eight years' time. Today at least a half billion dollars in annual damage is caused by air pollution to crop plants across the United States.

For a good many years, the late Mr. W. N. Noble worked for the Los Angeles County Air Pollution Control District, and was stationed at the Los Angeles State and County Arboretum (Lasca). His duties were to identify pollutants, pollution sources, and the effects of pollutants on various indicator plants. His work was used in proving specific damage from specific air pollution sources in court cases. He also observed and recorded the damage caused by smog to ornamental plants. *Grayia southerlandii* from South Africa has shown particularly bad damage at the Lasca. At Longwood, these same symptoms are observed on this species growing in our experimental greenhouse. It has also been observed in Edinburgh, Scotland, at the Botanic Gardens there! This is one of the susceptible plants we supplied for critical observation at the U.S.D.A. Beltsville Air Pollution Laboratory. One of the effects of smog shows up on the Chinese Elm in Pasadena, California where the leaves fall prematurely. This starts in the spring right after the new leaves mature and follows all through the season in response to heavy periods of smog incidence. The same symptom was noted at Longwood on a number of occasions, the latest being the July, 1970 east coast air pollution alert. Premature foliage drop occurred here on a number of species—elms, paulownias, sycamores. We always hear that sycamore is resistant to city fumes, and so it is to coal smoke and SO_2. It can't compete very well, however, with the Los Angeles smog.

The valleys of California fill with man-made air pollution emanating from the towns, settlements and highways nestled in those valleys. An approach to landing at the Los Angeles International Airport reveals the smog's upper layer and the clear sky above. The jet is not yet the largest contributor to photochemical air pollutants, but is one which is dramatically increasing in significance every day. It is calculated that one jet 707 air liner exhausts 5,000,000 cubic feet of gasses per minute. This is like having

Fig. 4. 'Pinto' bean. Leaf damage by ozone.

Fig. 5. Polluted air from a Pennsylvania steel mill trapped in a valley by temperature inversion.

more than 1,000,000 people standing on the runway breathing at the same time. No wonder the jumbo jets and SST's are being seriously questioned.

Power plants using soft coal, or the dregs of the petroleum refineries can and do smudge the beauty of the blue sky. In East St. Louis, it blackens both sides of the Mississippi River. That obvious source together with the less obvious but more virulent emissions from automobiles have reached concentrations sufficiently high to cause injury on the heretofore "resistant" *Ginkgo biloba.* A specimen at the Missouri Botanical Garden shows the typical zoning or banding which is so characteristic of conifer needle tip burn. You will recall that ginkgo is a conifer! This injury on ginkgo occurs in St. Louis, in Arcadia, California, and in Philadelphia. I can only emphasize that when an area becomes so saturated with man's own pollution as to damage ginkgo, then man who lives in those same conditions stands imperiled.

The Tea plant, *Thea sinensis*, shows a characteristic serious tip burn wherever it is grown under polluted conditions. Injury to certain varieties of *Syringa* has been reported from St. Louis, Rochester, New York, and the Brooklyn Botanic Garden. This injury can now be seen in every collection of lilacs in the Delaware Valley.

I stress that even the more resistant species can be injured when pollution concentrations are abnormally high, as during industrial accidents with weed killers or acid vapors. Such accidents occasionally reveal high resistance, however. Seedless ash trees were unhurt even when subjected to concentrations of hydrochloric acid vapors that devastated other trees nearby. *Euonymus bungeana* is a very pollution-resistant tree at the Missouri Botanical Garden. Many euonymus show this resistance.

In the Philadelphia area, my arrival in 1955 predated the advent of perceptible air pollution at Longwood Gardens. Since then, however, a huge refinery with an accompanying power plant complex to the south of us and a host of other pollutant producing industries, more power plants and increasing millions of automobiles have concentrated along the Delaware Valley. Each entity contributes increasingly to the now ever-present atmospheric pollution of the entire region. During the spring and summer of 1965, our first green plants at Longwood were injured by ozone, SO_2, other photochemical oxidants, and by fluorides. The number of plant species visibly injured now far exceeds 100. We are unable to grow several plants such as papaya to maturity for our displays in spite of the fact that we are still located in the country 20 miles from the nearest refinery and 30 miles from Philadelphia.

At Independence National Historical Park, Philadelphia, dogwood no longer serves as a satisfactory spring-flowering tree. It is injured so severely that it must virtually be replanted every spring—only to have its foliage burned back to the petioles by midsummer. This and the American Linden are only two of the historically important plants seriously injured in this, our national shrine, the city of brotherly love, now wondering how and where to celebrate the 200th anniversary of the nation's founding.

In Philadelphia, as already cited, ginkgo, the old reliable city street tree is no longer satisfactory. Although it was and is resistant to coal smoke and SO_2, it cannot survive under today's urban congestion

Fig. 6. Photochemical damage to *Ginkgo biloba*. Roosevelt Boulevard, Philadelphia.

dumping poisons into the air.

What is to be done? It has already been shown that a number of compounds sprayed on certain plants will help protect them from certain pollutants. Sodium ascorbate, for example, protects 'Pinto' beans from photochemical oxidant types. It has, indeed, been shown that plants naturally high in ascorbic acid, vitamin C, are apt to be resistant. But this is not the long-range solution to pollution. We must control air pollutants at their sources. We must select plants for natural resistance to the major pollutants, such as *Sophora japonica* and *Quercus phellos*. We must breed plants to further increase resistance.

Let it be clear, however, that we are not merely bemoaning the loss of "pretty plants" in modern society. WE ARE POINTING OUT OBVIOUS DAY-TO-DAY SYMPTOMS IN OUR VERY OWN GARDENS OF THE CRITICAL INTERNATIONAL PROBLEMS OF TODAY. Uncontrolled increases in population due to a drastically decreased death rate. Decrease in arable land brought about by erosion and the concreting and paving of millions of acres of land each year. Increasing amounts of pollutants each year in our air, water and soil. Disruption, impedance, and elimination of photosynthesis in and around metropolitan areas exceeding 50,000 inhabitants. This means that every breathing organism therein is becoming parasitic on the outside world for the oxygen it is taking in because photosynthesis is the only means by which our atmosphere can be kept in any semblance of balance. As grave as is the increasing shortage of oxygen so also is the geometrical rise in carbon dioxide from the burning of fossil fuels and the respiration of animals and plants.

We must increase the acreage of plants. They are our only major source of oxygen; they reconvert carbon dioxide. Plants absorb pollutants, such as SO_2, fluorides and chlorides. Plants precipitate from the air such particulate matter as dust, smoke and fly ash. Plants, through foliar evaporation, cool the surrounding air. They screen unsightly views and soften the harshness of concrete, brick, stone, asphalt, and aluminum siding. Plants mute noises and baffle harsh sounds. They have helped return a conscience and meaning to the human soul wherever they have been allowed to return and become an integral part of congested life. They do indeed pay their rent to the human species no matter how valuable be his property.

But, do we know which trees or herbaceous plants are the most efficient converters of carbon dioxide? Do we know which are the most efficient emitters of oxygen? I don't believe we do. It might be corn or alfalfa in the field. Some say it is the common poplar of Europe. Others favor sugar cane. Do we know which plants are most tolerant to the many man-made air pollutants in each of our climatic zones? I do not believe we do. We don't even know this about our own plants here in the most air-polluted country in the world. Nor do we know this about plant species which exist in the rest of the subarctic, temperate, subtropical and tropical worlds. Without this basic knowledge, how do we go about developing and breeding tailor-made vegetation for the vast spoiled areas which are now waste and contribute nothing, namely, mine dumps, submarginal drylands, denuded mountain slopes? Our needs for basic and applied research in this field are urgent, it seems to me.

Certainly, we must preserve green space and encourage more large parks and forest preserves. But the imperative global need for photosynthesis should be a compelling motive for more international cooperation. Because of the winter dormancy of temperate deciduous forests, it seems to me of really vital worldwide importance to preserve inviolate huge areas of tropical forests.

And at home? What is the first move? Give horticulture its appropriate place in our political and sociological studies of the urban crisis. Now is the time to substitute green plants for empty, useless buildings and abandoned areas of pavement. Yes, even for barren dismal expanses of open flat roofs throughout the cities. And now is the time to think of the thousands of people who might be gainfully occupied by caring for new plants in our cities and in keeping the surroundings so clean and beautiful. If I saw people doing this, then I would not feel so badly about the unfortunate souls who do nothing but draw their breath and their rations and throw their unemployment compensation envelopes into the street.

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Associates' News

Walks and Talks

The May walk, "Rhododendrons and Azaleas," due to the cold spring, did not reveal the usual voluptuous splash of color in the Azalea Meadow. Nevertheless, the pastel yellow *Rhododendron keiskei* gave welcome relief from the more garish shades of Glen Dale, Merritt and Chisholm hybrid azaleas.

The large majority of spring flowering trees and shrubs appeared to be flowering in prolific manner (but not our native dogwood, *Cornus florida*). The plants that attracted particular interest were *Daphne* x *burkwoodii*, *Magnolia obovata*, *M. liliflora*, *Virburnum carlcephalum* and the fragrant hybrid *V.* x *juddii.* It was a particularly fine year for *Halesia monticola rosea* which, regrettably, lost most of its flowers in a storm the day before the walk. The Arboretum is fortunate in having a number of species which give us the beauty of their flower in the spring and add a bonus of rich leaf coloring in the fall. In this category we were able to see *Enkianthus* spp. and *Fothergilla* spp. during May.

Pockets of color in the wall of the Rose garden were found in such plants as *Alyssoides utriculatum*, *Aubretia deltoides*, *Iberis sempervirens*, and *Asarina procumbens.* Above the wall are dainty clusters of *Tiarella cordifolia* and *T. wherryi.*

The most fervent discussion was prompted by a specimen of *Syringa persica laciniata*, a cut-leaf lilac.

The June walk took place in perfect weather during a lull between hot spells. Since many of the specialty gardens are to be restored over the next few years, most time was devoted to the Rose and Medicinal gardens. The newly restored half of the Rose Garden, containing a number of new cultivars, had flowered later than the established roses in the old section. Although relying upon such old favorites as 'Peace', 'Chrysler Imperial', and 'Charlotte Armstrong', the new section contains a number of recent introductions quite outstanding for their form and color. Most notable are the hybrid tea 'First Prize' and floribunda 'Zambra'.

The Medicinal garden is always popular, for who can resist a pinch and sniff of rosemary, thyme and sage. There are, of course, a number of specimens that offend the nostrils, still others that can do harm if eaten, so it is wise to remember that a knowledge of the plant is helpful if one wishes to indulge in such experiments.

Jarvis Fund

Thanks to a bequest of $15,000 recently received from the Joseph R. Jarvis Trust, a new capital fund has been established. The income of The Jarvis Fund will be used for educational and research purposes at the Arboretum. Mr. Jarvis, who was born in 1882, was a long-time friend of the Arboretum, possibly because of its features that nourished his life long interests in botanical and geological subjects. Although he graduated in mechanical engineering, through the years he took numerous courses in forestry, farming, and landscape architecture; geology and mining. He died July 2, 1969.

Philosophical Society Grant

A substantial grant ($6,350) has been made to Dr. H. L. Li by the American Philosophical Society (Michaux Fund) for 2 years for chemosystematic research on the American oaks. Mr. J. Y. Hsiao will assist Dr. Li in this study.

(Continued on page 50)

AUTUMN COLORATION AT THE MORRIS ARBORETUM

H. L. Li

Fig. 1. The meadow below Magnolia Slope is filled with the mists of an Autumn morning. William Wright photo.

Autumn is the most colorful season at the Arboretum, exceeding in brilliancy even spring's climax of flowering. At the beginning of our season which lasts from early September through October, a few flowering trees or shrubs are still coming into bloom. Later on as the temperature falls and days shorten, the foliage of deciduous trees begins to change color. Once a uniformly green canopy, the Arboretum becomes a splendor of swatches of yellow, brown, orange and scarlet. This mass coloration is further enhanced by the appearance here and there of clusters of variously colored fruits among the trees and shrubs.

The bright display of fall colors in the forests and countryside is a familiar sight to those living in this region of the country. Actually, this autumn coloration is limited to only a few parts of the world, notably the northeastern part of North America, temperate eastern Asia, and some parts of Central Europe. In the Arboretum, the many native species together with the numerous introductions from one of these areas, eastern Asia, give us in combination a greater variety of plants and coloration than found in the natural woods around us.

In the following enumerations, capital letters in parentheses after plant names refer to approximate locations as indicated on the accompanying map.

Autumn is not a season of flowers but the flower lover can still find a number of plants blooming. Some of the shrubs which start blooming in August may last into September or beyond such as *Clerodendron trichotomum*, *Franklinia alatamaha*, *Lagerstroemia indica*, *Euonymus kiautschovica*, and *Hibiscus syriacus*. A few others may begin to flower in these late months. Among these are *Escholtzia stauntoni* and *Lespedeza bicolor*, blossoming around early October; *Camellia sinensis* (Tea) and *Hamamelis virginiana* (Witch-hazel), around late October: and *Elaeagnus pungens* and *Osmanthus armatus*, around early November. Many kinds of heaths and heathers in the Heath Garden will also be in bloom during these months. The autumn blooming variety of the usually spring flowering Higan Cherry, *Prunus subhirtella autumnalis*, starts in late September.

A number of spring blooming trees or shrubs may experience a second flush of flowers in the autumn months, usually in September, including *Magnolia soulagiana*, *Wisteria*, *Weigela*, and white *Zenobia pulverulenta*. The hybrid Tea Roses, after a lapse of two months over July and August, will also put on another spectacular display in September.

Among the trees that show the most brilliant color in autumn are the many maples, sweet-gums (*Liquidambar*), Sassafras, Tupelo (*Nyssa*), Sorrel-tree (*Oxy-*

Fig. 2. Map showing locations of major Autumn displays. See text for explanation of letterings.

dendron), dogwoods, sumacs (*Rhus*), viburnums, Tulip-tree (*Liriodendron*), hickories, walnuts, oaks, birches and others. As these trees are scattered over the Arboretum, the entire grounds become arrayed with bright colors. The display is more brilliant in some years than others according to climatic conditions.

Among the more spectacular sights at the Arboretum are the double row of Scarlet Oaks (A) and the groves of *Sassafras* and *Nyssa* (B) along the western side of the Rose Garden. From there to the Old Mansion site, the area is designed as a fall color area with such trees as the Sugar Maple, *Photinia*, *Rhus*, Sorrel-tree, maples, Golden Larch, and others, all of which have brightly colored leaves in the autumn (C).

Many shrubby plants have brightly colored leaves in the fall, but as they are of much smaller sizes, they are not as showy as the trees. Among the shrubs, the most brightly colored leaves are found on the winged Spindle-tree, *Euonymus alata*. The crimson or rosy scarlet leaves are extremely showy. The plant also bears brightly colored fruits. It is also distinctive for its winged stems.

The Golden Larch, *Pseudolarix*, is the most brightly colored deciduous conifer. Its leaves turn bright yellow before falling. A large specimen is found along the edge of woods beside the Medicinal Garden (D). Other deciduous conifers have yellowish or brownish leaves, and though less brilliant than the Golden Larch, they also present impressive sights due to their frequent large sizes. Among these are the different species of larches, several large specimens being scattered throughout the grounds; the Ginkgo tree; and *Metasequoia*, a grove of which is located along the stream below the Medicinal Garden (E).

Of all genera, the most variable and interesting one in terms of autumn color is *Acer*, the maples. Their color varies from red to orange, yellow, and brown, or variegated with combinations of different shades. Some of the species cultivated at the Arboretum with these different colorations are listed below with the locations of the less common species. The specimens are generally scattered in all parts of the grounds.

Red:
- *Acer ginnala* (F)
- *A. griseum*
- *A. palmatum*, many forms.

Red and/or orange and red:
- *A. buergerianum* (G)
- *A. rubrum*
- *A saccharum*
- *A. spicatum* (H)

Orange or orange-yellow:

A. macrophyllum (I)
A. palmatum, many forms
A. truncatum (J)

Yellow:

A. campestre (K)
A. pennsylvanicum
A. platanoides
A. tataricum (L)
A. tegmentosum (M)

It should be noted that some species of maples also present foliage of varied colors during the year's normal growing season from late spring through early autumn. These distinctively colored and variegated forms are valued for specific ornamental purposes. The greatest variation of color is found in the Japanese maple, *Acer palmatum*.

Small colorful fruits, frequently referred to as "berries," plentifully abound on many of the smaller trees and shrubs in the Arboretum. The species are too many to be enumerated here. Some of the most important genera (locations indicated are for those with concentrated collections), which contain a large number of species with ornamental fruits are *Berberis*, the barberries (N); *Euonymus*, the staff-trees (O); *Ilex*, the hollies (P); *Lonicera*, the honeysuckles; *Mahonia* (Q); *Malus*, the crabapples (R); *Prunus*; *Pyracantha*, the firethorns; *Rhus*, the sumacs (S); *Rosa*, the roses; and *Viburnum* (T).

The greatest majority of the ornamental fruits are in various shades of red, orange, or yellow. Many fruits are darkly colored, varying from bluish- or purplish-black to black. White fruits are less common. Plants with white fruits are found in species ranging from those in the larger shrubby *Myrica*, the bayberries (U), to the smaller *Symphoricarpos* (V), and the low trailing *Epigea*, the Trailing Arbutus. Many other species commonly having colorful fruits may sometimes appear in white fruited forms.

Of unique color are the bright violet fruits of *Callicarpa*. Species such as *C. americana*, *C. bodinierei*, and *C. dichotoma* have small lilac-colored, highly ornamental fruits produced in showy clusters. A collection of these species is located near the former Mansion site (W). Also unique are the bright blue fruits of *Symplocos paniculata*, Asiatic Sweetleaf (X).

Among the berry fruited shrubs, the most valuable and noteworthy genus is *Viburnum*. A collection of the species can be found along the slope near the Baxter Memorial (Y). Other specimens are located on the opposite side of the Baxter Memorial and elsewhere. The fruits of the many species of this genus are all brilliantly colored, varying from crimson to vermillion to clear yellow. Others may have bluish

Fig. 3. The rosy leaves and startling fruit of *Euonymus alata* hang on in late October. John M. Fogg, Jr. photo.

fruits. Berries are usually abundant and thus present a very handsome appearance.

A very colorful and attractive combination is found in the fruits of many species of *Euonymus*, the staff-trees, and *Celastrus*, the bittersweets, which are either vines or erect shrubs or sometimes small trees. These species have fruits which are usually prolifically produced. The pods have a bright outer shell which splits open at maturity exposing the highly colorful and contrastingly colored seeds. In *Celastrus*, the outer shell is yellow and the seeds are red. In *Euonymus*, the outer shell is often pinkish-white or black. These fruits are among the most showy sights of autumn. Most of the species in these two genera are located in the area north of the Heath Garden (Z). Most of them also have vivid autumn foliage.

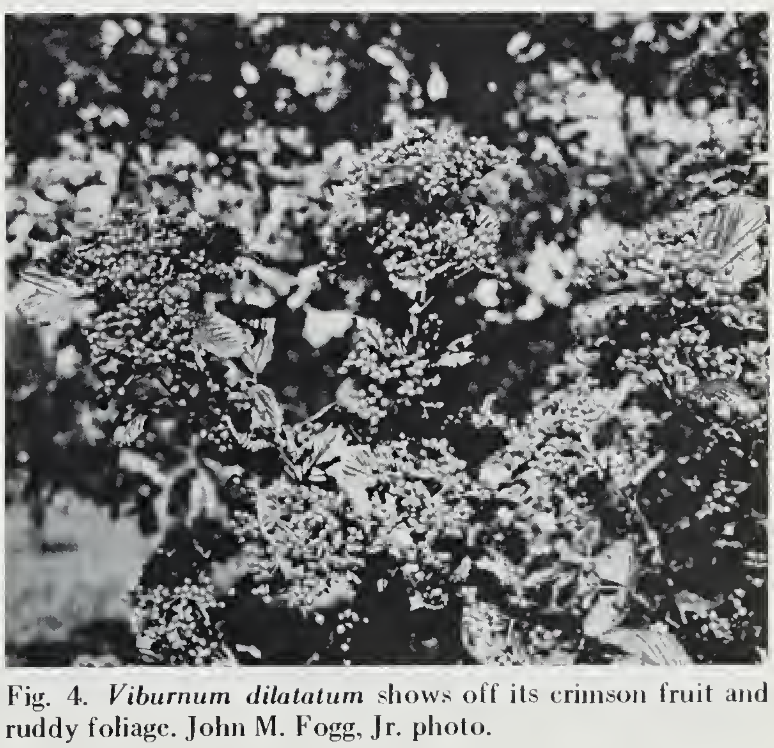

Fig. 4. *Viburnum dilatatum* shows off its crimson fruit and ruddy foliage. John M. Fogg, Jr. photo.

Book Review

GREAT BOTANICAL GARDENS OF THE WORLD. Text by Edward Hyams, photography by William MacQuitty. Thomas Nelson and Sons Ltd., London, 1969 (Available through MacMillan, New York.) 288 pp. $35.00.

This book, most appropriately titled, not only allows the enthusiastic gardener and botanist with time and money to plan a unique vacation touring botanic gardens throughout the world but gives those of us less fortunate in either or both of these categories an armchair vacation which is both absorbing and rewarding.

Mr. Hyams is a well-known British author who has not only contributed a number of volumes to the horticultural world but regularly contributes articles on other subjects to *The New Statesman* and other esteemed periodicals in Britain.

One is immediately attracted to this book by its cover photograph of the garden of Les Cédres in France. Ultimately I have come to regard this cover as a mere appetizer to the sumptuous feast of photographs within. The sixty-four pages in color are accurately and sharply reproduced and succeed in giving the reader a remarkable degree of involvement. It is quite impossible to adequately describe in words the diversity in symmetry, texture and color found in flowering plants and it is here that the greatest challenge is presented to a photographer. In this reviewer's experience, only rarely does one prove himself equal to the task. MacQuitty's plates in both color and black and white, with a few exceptions, demonstrate that he has, indeed, met this challenge ably, and, in some instances, with *stunning* success.

The color plates include pictures of *Victoria amazonica* at Kew and the Missouri Botanic Garden, and *V.* x 'Longwood' (An F_1 hybrid of *V. amazonica* and *V. cruciata*) taken at Longwood Gardens. 'Startling' is an inadequate adjective for the photographs of the Jade Vine, *Strongylodon macrobotrys* (Singapore Botanic Garden), the Torch Ginger, *Phaeomeria speciosa*, (Bogor Kebun Raya, Java), and the palms of Peradeniya in Ceylon. Specimens of some of the extraordinary species of tropical plants pictured grow in botanical gardens in this country. One example is the strange and fascinating "Cannon Ball Tree," *Couroupita guianensis*; though the photograph appearing in this volume was take in the Botanic Garden of Rio de Janeiro, a fine plant may be seen at the Fairchild Tropical Garden in Miami.

Although it is customary to deal with the text first in a review of such a book, it was felt that its greatest attraction to the reader was the collection of photographs therein. This is not meant to imply that the text is inferior, since any comparison of text and illustrations would be inappropriate.

It is evident that considerable historical research was necessary in order for Mr. Hyams to produce such interesting and colorful accounts of the many gardens detailed in the text. It is, however, surprising to find a number of small, yet irritating discrepancies. The incorrect spelling of some species, such as *Phellodendron lavalla* instead of *P. lavallei*, appears a number of times. This is, however, a common fault of many books and proves of less annoyance than reading that *James*, not Charles Sprague Sargent was the first director of the Arnold Arboretum! And surely the annual attendance quoted for the Brooklyn Botanic Garden is more than likely the number expected on a sunny day in May.

Because this reviewer is fortunate in having visited all the gardens in the U.S.A. and Great Britain and six of the other 16 European ones covered in the text, he finds it difficult to agree on a number of points, but one of the most stimulating experiences with this book is simply discovering whether or not your eyes "see" certain aspects of a garden in the same light as those of the author. There are large numbers of personal comments and details which one does not find in garden brochures. This makes the book easy and interesting reading.

One important comment, pertinent to all botanic gardens and arboreta, concerns Mr. Hyams' views on the Munich Botanic Garden; ". . . botanical gardens exist chiefly for the teaching and forwarding of botanical science, but some botanists are too apt to forget the 'garden' aspect. If the public is to be attracted and so instructed—and it is on the public after all that the gardens depend for funds—display and presentation are important." At Munich, ". . . botanists and gardeners have combined to serve the purposes of science while paying proper respect to art." This book should remind the horticulturist that his profession evolved from, and is still today largely dependent upon, the botanists.

Great Botanical Gardens of the World should be a long-term itinerary for all green-thumbed travellers and a useful volume to both botanist and horticulturist.

Angus Paxton Heeps

Announcements for Associates

COURSES IN BOTANY AND HORTICULTURE FOR THE FALL, 1971

The Morris Arboretum offers nontechnical courses on basic botany and horticulture that are designed for the Associates of the Arboretum and the general public. Each of them consists of six sessions that combine lectures, demonstrations, and practical experiences. Several courses are offered every Fall and Spring. You may select those that interest you most or may follow a plan of organized study that will earn the Botanical School Certificate.

For the Fall, 1971

5. FUNDAMENTALS OF ECOLOGY. DR. H. L. LI.
General principles of interactions of plants and environment; distinctive features of the plant communities of the world.
Mondays, 8–9:30 p.m., beginning September 27.
6. IMPORTANT PLANT FAMILIES. DR. A. E. SCHUYLER, Phila. Acad. Nat. Sci.
The family as a natural group; recognizing the unique characteristics of the most important families of flowering plants.
Tuesdays, 10–11:30 a.m., beginning September 28.
7. GARDENING PRACTICES. WILLIAM BRIENTNALL.
The planning, construction, and maintenance of the home garden.
Wednesdays, 10–11:30 a.m., beginning September 29.
8. FIELD STUDY OF THE FUNGI. DR. PATRICIA ALLISON.
Recognition of important fungi and analysis of their habitats.
There will be an introductory session followed by five weekly field trips.
Saturdays; first meeting at 10 a.m., September 25.

All classes will meet in Gates Hall, 9414 Meadowbrook Avenue, Philadelphia 19118, CH 7-5232. Fee: $25 per course for Associates, $30 for others, payable when registering. Register before September 22 by sending your name, address, zip, selection of courses, and check to The Morris Arboretum at the above address.

Complete Course Listing

1. Organization and Function of Plants
2. Classification of Plants
3. Molds, Mushrooms and the Environment
4. Plant Propagation
5. Fundamentals of Ecology
6. Important Plant Families
7. Gardening Practices
8. Field Study of the Fungi
9. Genetics and Plant Breeding
10. Plant Pathology
11. Conifers
12. Man's Uses and Misuses of Plants
13. Algae, Mosses, and Ferns
14. Seminar on Local Environmental Problems
100. Tutorial Botany

Tutorial Botany

The person registering for tutorial botany is given special opportunities for the independent exploration of a subject of his choice under the guidance of a staff member. The grounds, library, and laboratories will be available to such students. Completion of four courses (1, either 2 or 6, either 3 or 8, and 5) is required beforehand.

The Botanical School Certificate

The Certificate of the Botanical School is awarded to those who have completed a minimum of eight courses. These must include courses 9 and 13, one elective, and at least one term of tutorial botany.

AUTUMN WALKS AND TALKS

Associates are invited to participate in the autumn series of guided tours of parts of their Arboretum. These will be on Saturday mornings, 10 to 11:30. Meet at Gates Hall, then enjoy viewing the autumn-blooming plants (September 18), the vivid leaves and fruits of oriental and native trees and shrubs (October 16), and learn about the Arboretum's superb conifer collection (November 20).

Associates' News

(Continued from page 44)

Research Fund Gifts

Numerous friends of Marcella Sterling Van Burgh, who died recently, have contributed to the Morris Arboretum Research fund in her memory, for which the Arboretum is grateful.

New Roses

The redesigning and planting of the first half of the Rose Garden would not have been possible without the generous donation of over 800 plants from The Conard-Pyle Company of West Grove, Pa. and Jackson and Perkins of Medford, Oregon.

PLANTS COMMEMORATING PERSONS. II

LAGERSTROEMIA, THE OPULENT CRAPEMYRTLES

(part two)

Donald R. Egolf, Research Horticulturist
U. S. National Arboretum

Part one of this comprehensive essay appeared in the last issue of the Bulletin. *In it, Dr. Egolf introduced us to the crapemyrtles, to Magnus von Lagerstroem and Linnaeus, to aspects of culture and hardiness, and to some of the famous old specimen plants of early American Gardens. Now he continues with his discussion of care and research on new varieties. You will find not only an annotated list of the best cultivars but a directory of important gardens as well.*

Disease and Insect Problems

The most serious crapemyrtle disease problem is powdery mildew (*Erysiphe lagerstroemiae* West) which is most troublesome in the spring and fall months. The leaves, shoots, and flower buds become encrusted with a white powdery covering that will distort the shoot and leaf growth and prevent buds from opening. Since mildew is greatest during periods of high humidity and in areas of poor air drainage, the proper planting site and judicious pruning to maintain a plant with open growth habit will do much to reduce disease damage. One fungicide spray (Appendix, 1) is most effectively applied during the growing season to control mildew. Another (2) is best employed in the spring when the buds are swelling to destroy the mycelium that has wintered in the dormant bud. Other fungus diseases that are less frequently encountered are blotch or black-spot caused by a *Cercospora* species, leaf spot caused by *Cercospora lythracearum* Heald & Wolf, and tip blight caused by *Phyllosticta lagerstroemiae* Ell. & Ev.

In general, insect problems are less critical to the culture of crapemyrtle than mildew. Three insects which may become troublesome are crapemyrtle aphid (*Tinocallis kahawaluokalani* (Kirkaldy)), Japanese beetle (*Popillia japonica* Newman), and Florida wax scale (*Ceroplastes floridensis* Comstock). The crapemyrtle aphid exudes great amounts of honeydew which becomes the substrate for the sooty-mold fungus (*Capnodium* sp.). By controlling the aphid with a spray of insecticide (3, 4, 5), the unsightly sooty-mold is eliminated.

The Japanese beetle appears in mid-June in the Washington area; in other areas the date of appearance will vary. It can be controlled by a foliage spray (6, 5, 7). An additional spray may be required 3 weeks later if the Japanese beetle population persists. The reddish or purplish-brown Florida wax scale,

Fig. 7. The avenue of old pink crapemyrtles leading from the front of Claremont Manor to the James River is one of the most impressive plantings that reflects the grandeur and glory of landscape gardening of another century.

which for much of the year is covered with a thick waxy coating, can best be controlled by a malathion spray in early summer when the insect is in the crawler stage.

Research Developments

Few crapemyrtle cultivars were developed prior to the last decade. The pale pink color is the most common among the old specimens, and probably represents the original introduction type, but specimens with lavender and, rarely, white flowers are found. Many of the brilliant reds and dark pinks unquestionably have been chance seedlings located in such places as an old garden corner, a neglected cemetery, or an abandoned fence row that attracted attention and were specifically selected because of their color variance and brilliance. Throughout the years color variants have been found, introduced, neglected, and reintroduced to perpetuate recurrent confusion. Today many nurseries still list crapemyrtle only by color.

Cultivars are being developed through planned research programs. Research with crapemyrtle was pioneered by Otto Spring, Okmulgee, Oklahoma, who more than a decade ago began selecting and growing seedlings. He obtained selections with a diversity of growth characteristics which he has classified into: "Wee Wee," 4-5 inches; "Pee Wee," 9-10 inches; "Midget," 15 inches; "Very Dwarf," 2 feet; "Dwarf," 3 feet; and "Giant," 5 feet. (The double quotes do not indicate a cultivar selection or name.) The arbitrary division was based on the annual recovery growth made after the plants were cut to the ground. Many of these selections when unpruned and in the milder areas did not conform to this classification and matured to much greater heights. Among those given cultivar names are the 'Petite' groups: 'Petite Embers', 'Petite Orchid', 'Petite Pinkie', 'Petite Red Imp', 'Petite Ruby', and 'Petite Snow', which were State trademarked and introduced by Monrovia Nursery Company, Azusa, California. The dwarf types are a major contribution which, with the incorporation of disease resistance and greater hardiness, will provide a fine landscape plant. Two additional cultivars named are 'Majestic Orchid' and 'Maiden Blush'.

Fig. 8. The multicolored exfoliating trunks of crapemyrtle, as shown here at Claremont Manor, provide an interesting accent to any garden throughout the year.

A project of seedling production and evaluation has been initiated at the Los Angeles State and County Arboretum, Arcadia, California, where a number of seedlings are under trial.

Another crapemyrtle research project is being conducted by the Department of Horticulture and Forestry, University of Arkansas, at Fayetteville. The project is directed to the evaluation of selections of dwarf crapemyrtle for the southern United States and has 4 testing locations within the State. Public display plantings are at the Main Station of the Agricultural Experiment Station, Fayetteville, Arkansas; and at the Southwest Branch Station, Hope, Arkansas. A number of the Otto Spring dwarf selections as well as other seedlings are under test and evaluation at both stations.

In 1962 a crapemyrtle research project was initiated at the U. S. National Arboretum. Among the major objectives of this project are the production of cultivars with disease resistance, hardiness, recurrent flowering, true flower color, and diverse growth habit. Since the project was initiated, more than 70,000 seedlings have been grown for genetic study and selection. Six cultivars have been named: 'Catawba', 'Cherokee', 'Conestoga', 'Potomac', 'Powhatan', and 'Seminole' (Egolf, 1967, 1970). Brief descriptions of these are included in the appended list of recommended cultivars.

A large portion of the current National Arboretum investigation is concerned with mildew resistance studies. This work has been accelerated by the introduction of *L. fauriei* seed from Yakushima, Japan, in 1956 by the New Crops Research Branch, ARS, U. S. Department of Agriculture (U.S.D.A. Plant Inventory No. 165, 1966). Plants grown from this seed were distributed, among other points, to the National Arboretum and to Mr. B. M. Basham, Houston, Texas. It was soon observed at the National Arboretum that this plant was free of mildew and would hybridize with *L. indica.* Mr. Basham discovered seedlings under his plants which were carefully transplanted and nurtured to flowering in 1966. The Texas seedlings were alleged hybrids and they were found to be very similar to those later produced by controlled pollinations at the National Arboretum. The hybrid has flower and foliage characteristics intermediate between *L. fauriei* and *L. indica.* However, the flowers are small, white or lavender, and are borne over a long period. Although the F_1 hybrid has flowers that are inferior to those of *L. indica,* the plant has an upright, open trunk with smooth gray bark. Backcross and advanced generations of the hybrid, representing some 10,000 plants, are now being grown at the National Arboretum, and from such research and analysis, plants with better flowers, growth habits, disease resistance, and ornamental merit are being sought.

Crapemyrtle Species

Two other species, *L. subcostata* and *L. fauriei,* have approximately the same hardiness range as *L. indica.* The first, *L. subcostata,* is a much-branched tree that is native to Japan or Formosa. At Washington, D. C., the plant is frequently winter injured, but it sprouts profusely from the base and flowers as a small shrub. The pyramidal inflorescences, 3-8 inches long, are borne on the tips of the branches, giving the plant a billowy appearance. The small, white to rose-colored flowers are insignificant compared with those of *L. indica.* The plant has little to recommend it as an ornamental; however, it may be useful in breeding programs. A natural hybrid between *L. indica* and *L. subcostata,* occurring In Japan, has been named *L. amabilis* Makino. Selections of this hybrid with larger flowers are occasionally cultivated.

The second hardy species, *L. fauriei*, is not widely cultivated, although it warrants additional landscape use. *L. fauriei* (P.I. 237884) was collected at an elevation of 1,200 feet on a mountain forest above Kurio, Yakushima, Japan. According to John Creech, the collector of the seed, only a few trees of this endemic species were noted, and the plant would soon be extinct in the wild (Creech, 1958). More recently the National Arboretum has received additional collections from near Onoma, Yakushima, Japan. This species, with light green leaves that give the plant a lacy texture; small, early blooming, white flowers; trunks that peel annually to expose a satin-smooth, mottled, dark burgundy-cinnamon colored new bark; and mildew resistance, has opened a new area for developing many new and interesting hybrids. It is a rapid grower that develops a vase shape with outward arching branches and a height of more than 20 feet.

All other crapemyrtle species cultivated in the United States are restricted to the warmer areas of the South, particularly Southern Florida and California; all are more or less deciduous; and more often than not they attain tree dimensions. The most frequently cultivated species is *L. speciosa*, which is variably known as Queen's Crapemyrtle, Pride of India, June Rose, or Jarul. It is a native of India that has been dispersed throughout the tropics of the world. For centuries this species has been an important timber tree of Assam and India and it is second in value only to teak (*Tectona grandis* L.). *L. speciosa* grows in a wide range of tropical soils, but requires abundant moisture and sun. In its native habitat the plant is most abundant along river banks, fringes of forest, and scrublands up to 4,000 feet. The amount of free area given the Queen's Crapemyrtle will determine its branching. If planted closely, it will grow with a straight trunk; but with wide spacing the growth habit will be densely branching to spreading with a breadth of 20 feet or more. A young plant, staked to develop a leader, will rapidly grow to a height of more than 40 feet. When in flower, the Queen's Crapemyrtle is unquestionably one of the most spectacular of trees. Its flowering period may begin as early as May and occasionally lasts as late as August, with maximum flowering in June and July. The inflorescence is an erect panicle, usually 8-12 inches long, but sometimes 18 inches long. The 3-inch diameter flowers, which usually last 3 days, change color in the course of the day from delicate light rose in the morning to purple in late afternoon. Where the Queen's Crapemyrtle can be grown, there is no other crapemyrtle that can excel in beauty or landscape merit.

The person who has done most to introduce and disseminate the tree crapemyrtle species is Dr. Edwin

Fig. 9. *Lagerstroemia indica* 'Seminole', N.A. 30166, which is a dense, globose plant of medium growth habit, has clear, medium pink flowers that begin to open in mid-July before most cultivars.

A. Menninger, Stuart, Florida, who has further promoted the species with his accounts (Menninger, 1951, 1958, 1962). Peter Riedel (1957) provides additional notes on the species adaptable for extratropical regions. Species that have been cultivated in the United States are: *L. calyculata* Kurz.; *L. duperreana* Pierre ex Gagnep. (syn., *L. thorelii* Gagn.); *L. floribunda* Jack; *L. floribunda* Jack var. *brevifolia* Craib (syn., *L. turbinata* Koehne); *L. loudonii* Teysm. & Binn.; *L. microcarpa* Wight (syn., *L. lanceolata* Wall.); *L. parviflora* Roxb.; *L. reginae* Roxb. (syn., *L. hirsuta* (Lam.) Willd.); L. *tomentosa* Presl; *L. villosa* Wall. ex Kurz.

The cultivation of these various crapemyrtle species is greatly restricted by climatic conditions, but they merit greater landscape planting and testing in the adaptable areas. Likewise, the exploration and introduction of natural (ecotypical) variants of the above species, as well as other species not now cultivated, may yield plants more suited to cultivation; provide stocks for breeding programs; and material of great ornamental merit.

Cultivars of L. indica

The following cultivar list includes the best in each color and growth habit class, but is not intended as a checklist of all cultivars. These are arranged alphabetically with a brief note on flower color, growth habit, or other significant characteristic. The growth habit categories are approximately: Dwarf (D), less than 3 feet; Semi-dwarf (S-D), under 6 feet; Medium (M), 6-12 feet; and Tall (T), 12 feet or more. (N.A.= National Arboretum accession number.)

'Carolina Beauty'—Deep, bright red; (M).

'Catawba' (N.A. 28861)—Dark purple; dark green foliage; highly mildew resistant; brilliant orange-red autumn foliage; (M).

'Cherokee' (N.A. 30167)—Brilliant clear red; truest red color of any crapemyrtle; (M).

'Conestoga' (N.A. 28862)—Long, tapered inflorescences; multicolored medium to light lavender; open growth; (M).

'Country Red'—Dark red; similar to 'Watermelon Red'; (T).

'Dallas Red'—Dark red; upright; (T).

'Dixie Brilliant'—Rich, deep watermelon red; (T).

'Durant Red'—Pure red; (T).

'Dwarf Blue'—Lavender-blue flowers; (S-D).

'Firebird'—Deep watermelon red; broad spreading; (S-D).

'Glendora White'—Large, showy white with faint pink tint; (T).

'Gray's Red'—Rich red; upright; (T).

'Imperial Pink'—Light, pastel pink; (M).

'Kellogg's Purple'—Rich purple; upright; (T).

'Low Flame'—Bright red; (S-D).

'Majestic Orchid'—Rich orchid; vigorous; upright; (T).

'Near East'—Flesh pink; long flowering season; vigorous; spreading growth habit; (M).

'New Snow'—White; (S-D).

'Petite Embers'—Rose red; (D).

'Petite Orchid'—Dark orchid; (D).

'Petite Pinkie'—Clear pink; (D).

'Petite Red Imp'—Dark red; (D).

'Petite Ruby'—Deep ruby red; (D).

'Petite Snow'—White; (D).

'Pink Lace'—Clear bright pink; similar to 'Near East'; (M).

'Pink Ruffles'—Rosy-pink; (D).

'Potomac' (N.A. 28863)—Clear medium pink; long flowering season with recurrent bloom; highly mildew resistant; upright, vigorous; (T).

'Powhatan' (N.A. 28864)—Light lavender; highly mildew resistant; (M).

'Red Star'—Deep watermelon red; long flower panicle; similar to 'William Toovey'; (T).

'Royalty'—Rich royal-purple; (D).

Fig. 10. *Lagerstroemia indica* 'Conestoga', N.A. 28862, has abundant, long tapered, medium to pale lavender flowers creating a multiple-colored inflorescence.

'Seminole' (N.A. 30166)—Clear, medium pink; abundant, large inflorescences; recurrent bloom; highly mildew resistant; (M).

'Shell Pink'—Pale pink; similar to 'Near East'; (M).

'Snow Baby'—Pure white; (D).

'Tiny Fire'—Rich red; (D).

'Twilight'—Dark purple; less hardy than most; upright; (M).

'Watermelon Red'—Dark pink watermelon; refers to many variants with dark pink or red flowers; similar to 'William Toovey'; (T).

'William Toovey'—Dark watermelon; plant typical of the many red variants cultivated under diverse cultivar names; (T).

'White Cloud'—White, tinged pink; (T).

Garden Directory

The number of gardens featuring crapemyrtle or that have a major collection of cultivars is very small. Frequently those gardens with a number of plants have at most only a few color variants. More recent plantings at arboreta and botanic gardens often in-

clude named cultivars of greater color range. The following garden list includes those open to the public which have sufficient plants for a spectacular floral display. Additional crapemyrtle displays frequently are observed in highway beautification projects or in communities which have sponsored crapemyrtle plantings, such as those listed earlier in the text under landscape uses.

Philadelphia, Pennsylvania, and vicinity have scattered specimens in sheltered private gardens. The Morris Arboretum and the Arboretum of the Barnes Foundation have a few specimens, but these are neither of great age nor size.

Baltimore, Maryland, and vicinity is near the hardiness borderline for crapemyrtle, but specimens can be seen at such places as Hampton National Historical Site and Gardens, Towson; Kernewood; Montebello Filtration Plant; and Clifton Park in Baltimore.

U. S. National Arboretum, Washington, D. C., has a collection of cultivars, hardy species, and hybrid seedlings produced by the research program.

Pokety Farms and Gardens, near Cambridge, Maryland, was created in 1930 to feature crapemyrtle by the late Walter P. Chrysler, who moved 125 ten-foot trees from Georgia. The garden contains some 250 specimens, many of great age, including diverse spontaneous seedlings. This unique collection offers the most spectacular crapemyrtle display of any American garden and has on occasion been opened to the public for charity purposes.

Gunston Hall, Lorton, Virginia, the eighteenth century residence of George Mason, has a formal garden featuring boxwood which has been restored by the Garden Club of Virginia. Included in the garden and surrounding landscape are some large specimens and groups of crapemyrtle.

Eyre Hall, Cape Charles, Virginia, has a formal garden over 100 years old with an allée of crapemyrtle that includes specimens of great age.

Stratford Hall, Stratford, Virginia, which is now a national shrine under the direction of the Robert E. Lee Memorial Foundation, Inc., has one of the oldest crapemyrtles and some fine specimen crapemyrtles in the formal garden which has been restored under the guidance of the Garden Club of Virginia.

Elmington Estate, Elmington, Gloucester, Virginia, has several specimens estimated to be 48 feet tall planted near the mansion. Several additional plants of lesser size are included in the garden which is open to the public the last week of April for Garden week.

In gardens at Williamsburg, Virginia, and vicinity are some fine crapemyrtle specimens; for example, at Allen-Byrd House, Archibald-Blair House, Public Records Office near the Capitol, and William and Mary College. Carters Grove, which also is managed by Colonial Williamsburg, has an avenue planting of fine specimens.

Chippokes Plantation State Park, Surry, Virginia, has a formal garden that was planted about 1920 that features crapemyrtle, boxwood, and azaleas. The magnificent multicolored crapemyrtle trunks dominate the garden, and from within the garden the overhead canopy of flowers is obscured.

Claremont Manor, Claremont, Virginia, which is now owned by the Felician Sisters, O.S.F., is a historic seventeenth century manor located in a 10-acre park of formal gardens in which there are fine old horticultural specimens. An awe-inspiring avenue of mammoth crapemyrtle specimens leads from the front of the manor to the banks of the James River. In addition, excellent specimens provide focal points elsewhere in the landscape. The garden is not open to the public at any specified time; however, permission is granted to interested persons or groups upon request.

Chinqua-Penn Plantation House and Upper Piedmont Research Station, Route 3, Reidsville, North Carolina, has 100-150 crapemyrtles growing in the garden or along the highway.

Tryon Palace, New Bern, North Carolina, the first capitol of the colony, completed in 1770, has a restored garden which includes kinds of ornamentals grown in the late eighteenth century among which are relatively young crapemyrtles trained as standards.

The Hermitage, Ladies Hermitage Association, Hermitage, Tennessee, the home of Andrew Jackson, dating from 1819, has approximately 50 pink crapemyrtles in the garden.

The Sam Davis Home, Sam Davis Memorial Home Association, Smyrna, Tennessee, has a garden typical of the ante-bellum houses with beautiful pink crapemyrtle planted in the late 1930's.

Magnolia Gardens, Charleston, South Carolina, which were designed by the Rev. John Drayton in the 1830's, are most renowned for magnolias, camellias, and azaleas, but have splendid crapemyrtles for prolonged summer floral display.

Middleburg Plantation, Huger, South Carolina, a great river rice plantation garden of the late seventeenth century, has large specimen crapemyrtle. The American Forestry Association's champion crapemyrtle is located in this garden.

Middleton Gardens, Middleton Place, Charleston, South Carolina, the oldest garden in America which was developed by Henry Middleton, the first Continental Congress President, and which has cultivated plants introduced by Michaux, has very old crapemyrtle specimens of great size and of several colors.

Fig. 11. Located at the corners of the Elmington Estate mansion are two fine red crapemyrtles that are as high as the roof and estimated to be 48 feet tall.

Callaway Gardens, Pine Mountain, Georgia, which was established by the late Cason J. Callaway as a memorial to his mother, Ida Cason Callaway, and opened to the public in 1952, has the entrance flanked with 'Near East' crapemyrtle as well as specimen plants in the landscape.

Bellingrath Gardens, Theodore, Alabama, which were developed by the late Mr. & Mrs. Walter D. Bellingrath, are most noted for the azaleas and camellias but have a fine crapemyrtle display in summer.

Ivy Green, 301 W. Almon Avenue, Tuscumbia, Alabama, the birthplace of Helen Keller, was built in 1820: the plantings around the house indicate they were planted soon after this date. A number of pink and white crapemyrtles of great age are included in the garden.

Cottage Plantation, St. Francisville, Louisiana, which was established in 1795, includes many crapemyrtles 25-30 feet tall.

Hodges Gardens, Many, Louisiana, have no old specimen crapemyrtles, but do have a collection of recent cultivars planted singly or in groups.

Jungle Gardens, Estate of E. A. McIlhenny, Avery Island, Louisiana, include a number of color forms for summer bloom in the garden.

Rip Van Winkle Gardens, Jefferson Island, Louisiana, which include specimen light pink crapemyrtle that were introduced prior to 1917, have a collection of recent cultivars.

Rosedown Plantation and Gardens, St. Francisville, Louisiana, an estate typical of the first half of the nineteenth century with extensive gardens that have been restored to their original splendor, have large specimen crapemyrtles.

Fairchild Tropical Garden, Coconut Grove, Florida, which was established in 1935 as a tribute to David Fairchild, has specimen plants of crapemyrtle species as well as cultivars of *L. indica.*

U. S. Plant Introduction Garden, 13601 Old Cutler Road, Miami, Florida, has species of crapemyrtle as well as cultivars of *L. indica* included in the trial garden.

Will Rogers Horticultural Gardens, Oklahoma City, Oklahoma, have an extensive collection of crapemyrtle cultivars which are not old but include a diversity of types.

William Land Park and Fairy Tale Town, Sacramento, California, have a number of 40-50 year old

plants that are mostly pink.

Los Angeles State and County Arboretum, Arcadia, California, which first planted crapemyrtle in 1951, has a collection of cultivars and seedlings.

Data Request

The locations of many of the fine old crapemyrtle specimens have been uncovered, but as of this date few data have been procured. Such crapemyrtles are not only of historical interest, but also may provide germplasm for hybridization. The U. S. National Arboretum is compiling data and requests anyone familiar with the location of specimen plants to forward any available data on size of plant, color of flower, date of planting if known, and other historical data to the U. S. National Arboretum, Washington, D. C. 20002.

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Appendix

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and it does not imply approval to the exclusion of other products that may also be suitable.

All agricultural chemicals recommended for use in this report have been registered. They should be applied in accordance with the directions on the manufacturer's label as registered under the Federal Insecticide, Fungicide, and Rodenticide Act.

1. 2-(1-methylheptyl)-4, 6-dinitro-phenyl crotonate [dinocap, Karathane,] Karathane is the trademark name for a formulation of dinocap sold by Rohm and Haas, Philadelphia, Pennsylvania. It is applied at the rate of ½ lb. per 100 gal. water.

2. Calcium tetrasulfide, calcium pentasulfide [lime sulfur (30% calcium polysulfide and various small amounts of calcium thiosulfate plus water and free sulfur), 1 to 80 dilution].

3. 6,7,8,9,10,10-hexachloro-1,5,5a-6,9,9a-hexahydro-6, 9-methano-2,-4,3-benzodioxathiepin 3-oxide [endosulfan, Thiodan]. Thiodan is the trademark name for a formulation of endosulfan sold by FMC Corp., Niagara Chem. Div., Middleport, N. Y.

4. 1,2,3,4,5,6-hexachlorocyclohexane, consisting of several isomers and containing a specified percentage of *gamma* isomer (benzene hexachloride) [lindane, *gamma* BHC].

5. *S*-[1,2-bis (ethoxycarbonyl) ethyl] *O*, *O*-dimethyl phosphorodithioate [malathion].

6. 1-naphthyl methylcarbamate [carbaryl, Sevin]. Sevin is the trademark name for a formulation of carbaryl sold by Union Carbide Corp., New York, N. Y.

7. 1,1,1-trichloro-2,2,-bis (p-methoxyphenyl) ethane [methoxychlor, Marlate]. Marlate is the trademark name for a formulation of methoxychlor sold by E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Cyanide Production in Magnolia

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AND

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The production of HCN (hydrocyanic, or prussic, acid) by plants has been known for many years. The earliest record of cyanogenesis being used for plant classification dates back to 1830 (Gibbs, 1963). Recent chemotaxonomic research (Hegnauer, 1958) has indicated that the character of cyanogenesis is not likely to be useful in solving major phylogenetic problems. However, Hegnauer (1961) has stressed the value of cyanogenesis in the typification and identification of cultivars or clones of cultivated plants.

Hydrocyanic acid is known to be produced in the leaves of more than 80 families of angiosperms, and is also found in gymnosperms. Some common plants that produce HCN are flax (*Linum*), plane (*Platanus*), dawn redwood (*Metasequoia*), and cherry (*Prunus*). The chemical nature of the cyanogenetic compound is not known for most plants, but Dillemann (1958) has listed and classified those compounds that have been determined.

Although there have been no previous reports of HCN in *Magnolia*, some positive results have been obtained from related genera. Greshoff (1909) reported HCN in *Liriodendron tulipifera* L. (tuliptree) and *L. chinense* (Hemsl.) Sarg. of the Magnoliaceae. Smith and White (1918) found HCN in *Drimys dipetala* F. v.M., which is now placed in the Winteraceae.

Our present survey of *Magnolia* species and cultivars was undertaken to determine the existence of cyanogenesis and the possible utility of this character as a marker in our breeding and selection program.

MATERIALS AND METHODS

Young leaves, less than one-half full size, were collected in May from plants growing on the grounds or in the greenhouses of the National Arboretum. Only 1 or 2 plants of each species or cultivar were tested, but each plant was tested twice. The leaf material was cut into small pieces, and about 0.5 g. was placed in a test tube fitted with a ground glass stopper. A strip of Whatman No. 1 filter paper was attached to the underside of the stopper with melted paraffin wax. Just before the test, the paper strip was dipped in a sodium picrate solution (25 g. sodium carbonate and

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5 g. picric acid in 1 liter), and allowed to air-dry for a few minutes.

Four or 5 drops of chloroform were then added to the leaf material, the stopper (with the moist paper strip) was inserted, and the tube was placed in an incubator at 30°C. Release of HCN from the leaves causes the yellow sodium picrate to turn red. In our work, development of the red-brown color within 24 hours was considered a positive test.

Some researchers (Gibbs, 1961) also add a solution of the enzyme emulsin (β-glucosidase) to aid in hydrolyzing the cyanogenetic glycoside. Our tests on *Liriodendron* indicated that β-glucosidase was not effective in enhancing hydrolysis, and in some cases seemed to inhibit HCN production.

Results and Discussion

Of 16 species and cultivars examined, only *M. sprengeri* Pampan. 'Diva' gave a positive test for HCN.

The following species, in various sections, gave negative tests.

SUBGENUS MAGNOLIA

Section	Species
Gwillimia	*M. coco* (Lour.) DC.
Rytidospermum	*M. macrophylla* Michx.
	M. obovata Thunb.
	M. pyramidata Bartram
	M. tripetala L.
Magnoliastrum	*M. virginiana* L.
Oyama	*M. sieboldii* K. Koch
Theorhodon	*M. grandiflora* L.
	M. guatemalensis Donn. Smith

SUBGENUS PLEUROCHASMA

Section	Species
Yulania	*M. denudata* Desr.
Buergeria	*M. kobus* DC.
	M. stellata (Sieb. & Zucc.) Maxim.
Tulipastrum	*M. acuminata* L.
	M. cordata Michx.
	M. liliflora Desr. ex. Lam.

Since *M. sprengeri* belongs to the section Yulania, we also tested the interspecific hybrid *M.* x *veitchii* Bean (*denudata* x *campbellii* Hook. f. & Thoms.) of this section, as well as 5 cultivars of *M.* x *soulangiana* Soul. derived from hybridization between *M. denudata* of section Yulania and *M. liliflora* of section Tulipastrum. All of these cultivars gave negative tests. No other members of section Yulania are hardy in the Washington, D.C., area, nor were any available in the Arboretum's protected greenhouse collection.

Although we hoped that HCN production could be used as a chemical indicator of true hybrids with 'Diva', the existence of cyanogenesis in progenies derived from 'Diva' provided no clear inheritance pattern. Young plants that had not yet reached flowering age were provided for this study by Arboretum breeder, Mr. William F. Kosar. Three seedlings grown from open-pollinated (presumably selfed) seed of 'Diva' were tested, and only one showed cyanogenesis. Likewise only one of two putative *liliflora* x 'Diva' hybrids and one of two putative 'Diva' x *denudata* hybrids produced HCN. In addition, a single seedling of 'Diva' x *kobus* produced no HCN.

It would appear that the gene(s) controlling production of the cyanogenetic glycoside is dominant, but that 'Diva' is heterozygous. Since 'Diva' is a hexaploid (6x) with 2n=114 chromosomes, it would have at least 6 genes dealing with glycoside production. If we assume, for the sake of discussion, that 'Diva' has 3 dominant alleles and 3 recessives, and that at least 3 dominants were necessary for cyanogenesis, self-pollination (with random chromosome distribution) would result in a population in which more than 25% of the plants did not produce the cyanogenetic glycoside. Hybridization with non-cyanogenetic species of any ploidy level would also produce a high proportion of non-cyanogenetic progeny.

It should also be remembered that the detection of HCN in our test depends on the presence of the hydroloyzing enzyme, which is also governed by at least one allelic gene pair.

Thus, although the presence of HCN in putative hybrids where 'Diva' was the male parent (as in *liliflora* x 'Diva', above) is an indicator of true hybridity, HCN will not be found in *all* true hybrids with 'Diva'. However, HCN production may well be used as a key character to distinguish certain improved hybrid cultivars, involving 'Diva', originated by the *Magnolia* breeding program.

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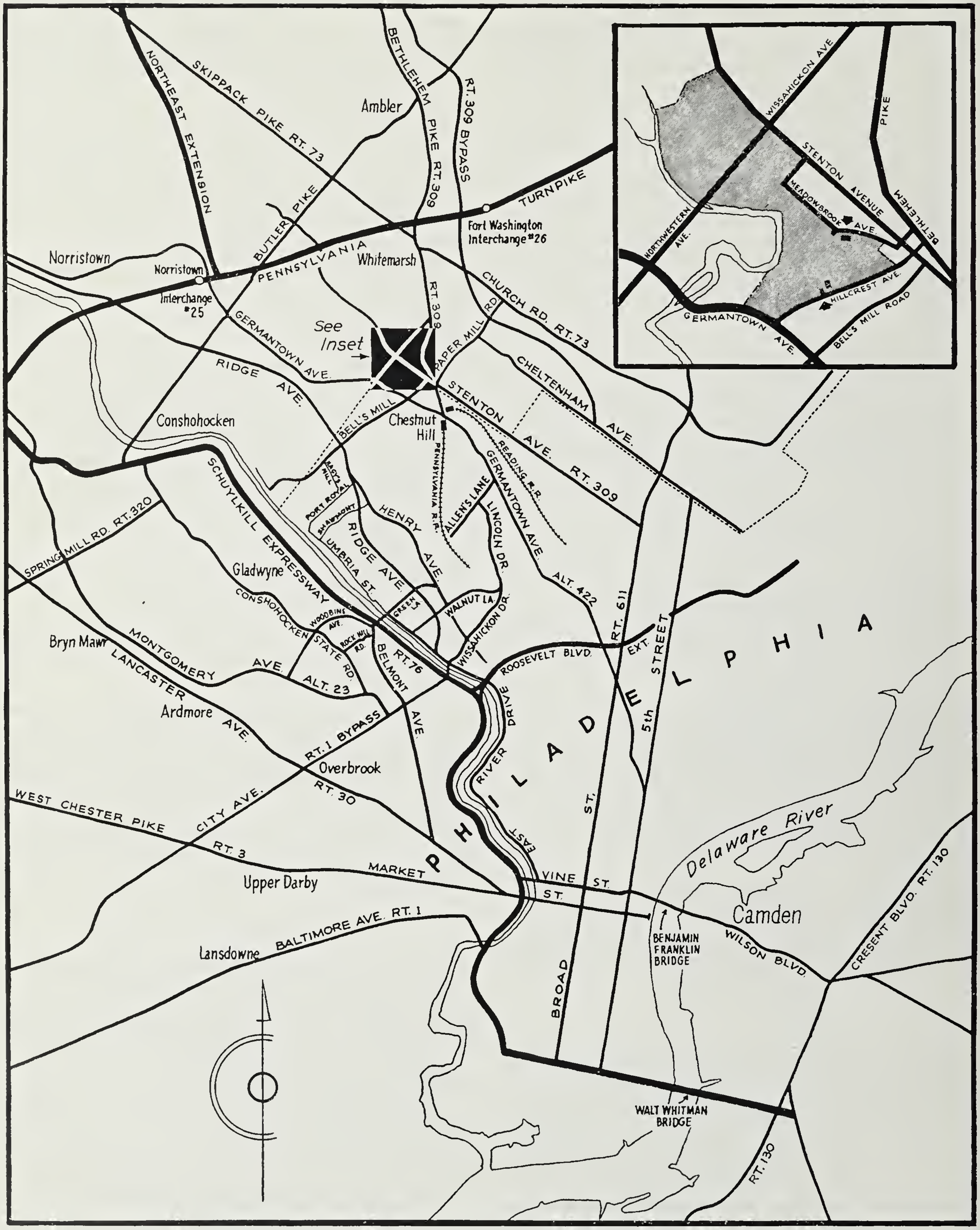

MAP SHOWING ACCESS TO THE MORRIS ARBORETUM, PHILADELPHIA, PA.

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MORRIS ARBORETUM

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

TYPES OF MEMBERSHIP

Contributing	$10.00 a year	Supporting	$25.00 a year
Family	$15.00 a year	Sponsoring	$100.00 a year
Donor	$500.00		

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COVER: The "Three Crones" of the Morris Arboretum stand gossiping in the winter snow. *Pseudotsuga menziesii glauca.* Photo by William Wright, Arboretum gardener.

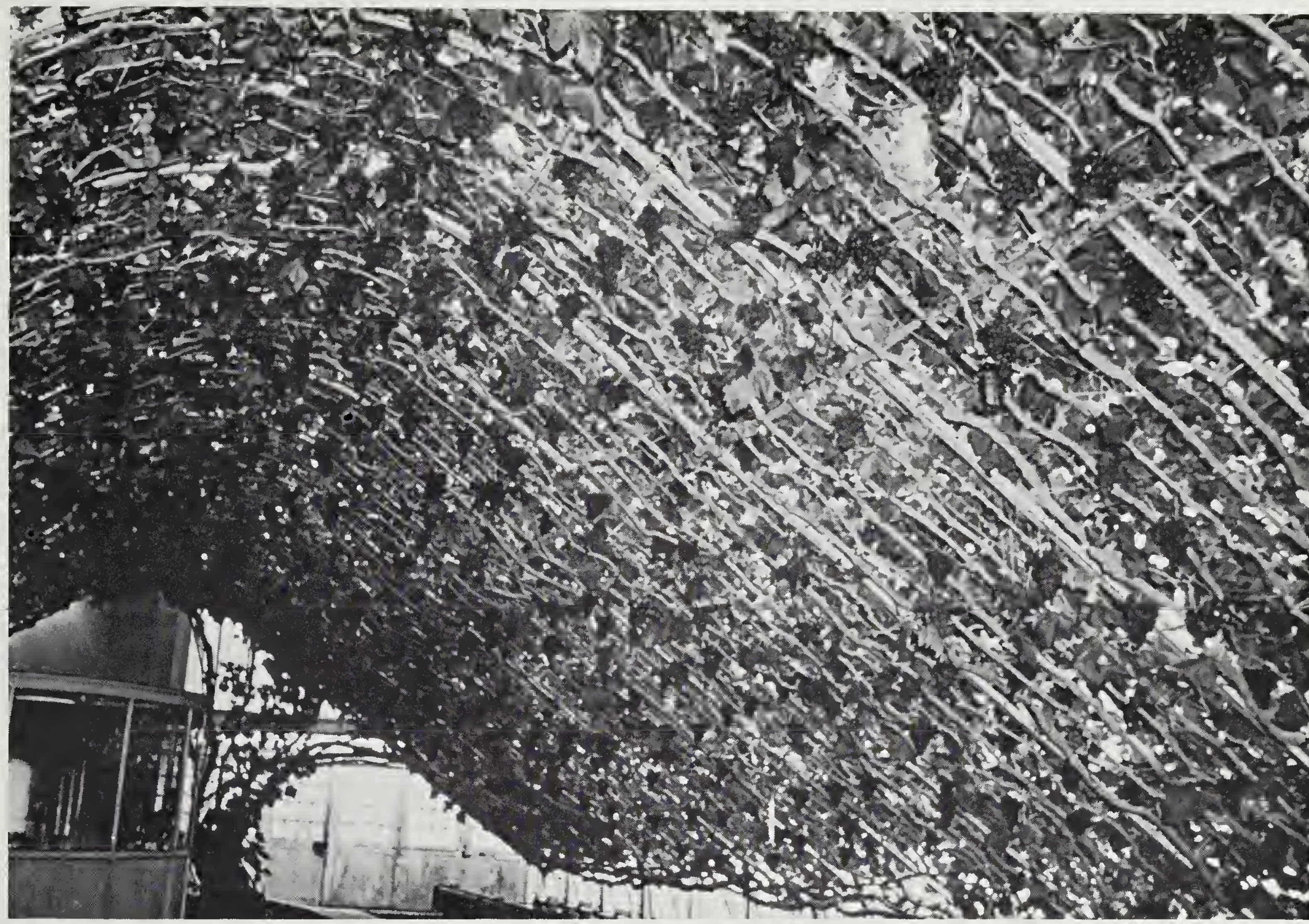

Fig. 1. A portion of the ancient 'Black Hamburg' vine at Hampton Court. Each year 600 bunches of grapes are allowed to ripen. (Walton Photog. Supp. Ltd.)

The Great Vine at Hampton Court Palace

George W. Edwards

Hampton Court Palace is situated on the river Thames about 20 miles to the West of London; it was built by Cardinal Wolsey who presented it to King Henry VIII. For 250 years this palace was a favourite residence of the English kings and queens. Today visitors can wander through the State Apartments, visit the chapel where Henry VIII married his last two wives, and traverse the corridor, still said to be haunted by the ghost of his fifth wife vainly seeking the faithless monarch. In its Great Hall, Shakespeare and his companions played before James I; below the Hall is the wine cellar, still with the stands which held the 260 gallon wine tuns. One can even enjoy watching tennis (not lawn tennis) being played in England's oldest covered tennis court, saunter by the herbaceous borders gay with flowers at all seasons of the year, or try to find one's way around the Maze, but it is the Great Vine which draws the largest number of visitors, with its 'Black Hamburg' grapes ripening throughout the summer season.

In the autumn of 1969 it was necessary to rebuild the Vine House. The problem was to complete the work, after the harvesting of the grapes, but before the bad weather set in. This was successfully accomplished by using pre-fabricated sections, one section of the house being demolished at a time and the new section inserted and glazed before passing to the next. The whole operation was completed between October 20 and December 12.

What is the origin of this famous vine which has grown here for over 200 years, now 78 inches in girth and 114 feet in length? In the early years of the 18th

century two brothers, John and Simeon Warner, were engaged in shipping and general merchandising in the South London district of Rotherhithe. Among their neighbors was John Haddon, whose daughter Elizabeth emigrated to New Jersey in 1702; her farmstead has developed into the town of Haddonfield. John Warner was a keen amateur gardener and cultivated a large garden by the Thames, where he specialized in growing fruit trees—there is still an apple named 'Warner King' said to have originated from this garden. Warner was generous in giving seedlings to his friends, and received cuttings in return. It was about the year 1720 that John Warner received from Hamburg a cutting of the Burgundy grape vine, which he found ripened against a wall earlier than any other. He took cuttings and grew them as standards. These succeeded beyond his expectations; he considerably enlarged his vineyard, and gave cuttings from his vine to any who would plant them. Among his friends was a Samuel Wilson who was a wine merchant. It is thought that Warner and Wilson contemplated a wine trade based on English grown grapes, but the alliance with Portugal, which allowed the importation of port wine into England, made the project uneconomical. Samuel Wilson is still remembered in the City of London because he left a fund to assist young men to improve their businesses; the Lord Mayors of London still help in administrating this fund.

Peter Collinson (*Morris Arboretum Bulletin* 21:41-44) was another friend of John Warner's who exchanged cuttings with him.

John's brother, Simeon, had married a lady from Germany; their daughter married a Jacob Hagen from Hamburg, who settled in England. These Hamburg relatives provide the clue for the source of the original cutting. Though Hamburg is not a wine producing area, the vine could have been taken there from Burgundy, and grown in a "stove" or glasshouse. Among the recipients of cuttings from John Warner's vine was Sir Charles Raymond, who in 1758 planted it on his Ilford Estate in Essex. It flourished here for more than 150 years. It was in 1768 that a cutting from this Ilford vine was given to Capability Brown who planted it at Hampton Court where it still produces many bunches of grapes annually, and gives much pleasure to many visitors.

The Friends John Warner, his brother Simeon with Jacob Hagen, Samuel Wilson, Peter Collinson, and John Haddon are all buried near one another in the Quaker Burial Ground, Long Lane, Bermondsey, London.

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Dictionary of National Biography, Eng.
H. W. Longfellow poem "Elizabeth."
Samuel Wilson Trust. Guildhall, London.
Records Society of Friends, Friends House, London.
Journals of Royal Horticultural Society, London.

About Our Authors

H. L. Li, Acting Director since the beginning of the year, completes his four-part handbook of seasonal glimpses of the Arboretum.

David A. Caccia is a talented resident of New Jersey who, seven years ago, moved with his family to a homestead in the woods. His varied training—mechanical engineering and art—let him leave the 9 to 5 world and devote his time to building his house, growing his food, writing, sculpting and photographing.

P. M. Miller, Ph. D. Illinois, has attained an extraordinarily balanced insight into the implications of plant disease problems. His research and writings reveal an awareness that what is most practical for commercial growers might be most impractical for home-owners, and vice versa. He reports that the use of marigolds offers an easy control for the most common nematode in Connecticut gardens.

George W. Edwards is the author of an earlier article about Peter Collinson. In subsequent correspondence with the editor he remarked about an essay he had read about the Hampton Court Vine, "The writer stated that the original vine was introduced to England in 1720 by John Warner, who had it in his garden in South London—then somewhat more rural than at present!—This rang a bell for me and I was able to turn up my notes on John Warner, who was a Bermondsey Quaker and a personal friend of Peter Collinson." Mr. Edwards is a Trustee of The Bermondsey Burial Ground.

Associates' News

Marion W. Rivinus

The New Arboretum Garden Club Membership

The garden clubs of greater Philadelphia, and we hope especially the Chestnut Hill ones, can now join the Morris Arboretum *as clubs* for $35 a year. The advantage of this will be that the Member Club may hold at least one meeting a year at the Arboretum free of charge. The regular fee for this is $20 to $50, depending on size.

Also, the Staff of the Arboretum will be willing to help from time to time in the planning of programs or club projects. Even the individual members of the garden club will benefit because the regular Associates' dues will be reduced by 20% for them.

The Courses in Botany and Horticulture

The new courses in Botany and Horticulture listed in the September *Bulletin* have been worked out very carefully to cater to both men and women. Some are scheduled for evenings and Saturdays. There is a great variety of subjects: ecology, plant families, history, function, even propagation, pathology, gardening practices and actual field trips. For those who wish to continue in more detail with private studies, a member of the Staff will advise in Tutorial Botany, and, of course, allow the student the use of grounds, laboratories, and library. Another special offering is the Botanical School Certificate Program.

The course Number 14 listed as the "Seminar on Local Environmental Problems" should appeal particularly to members of this community and hopefully help provide a basis for positive action.

All these courses, whether taken individually or as an organized series, offer unique opportunities. Besides, the Arboretum is easily accessible and there is peaceful parking.

New Financial Disclosure

The Arboretum has had a number of inquiries from persons interested in the furtherance of its activities and goals. Here in this issue for the first time is an Operating Statement for The Morris Fund.

Clearly, we must develop realistic support for the Arboretum.

The Otto T. Mallery Bequest

Dr. Li has just learned that the late Otto T. Mallery provided for the payment of $5000 to the Arboretum for the express purpose of improving the Rose Garden fountain and other architectural embellishments of the Rose Garden, or for benches and other items that would make the Arboretum more attractive to the public. This has proved to be a most timely gift, as the decrepit plumbing to the lovely, bronze fountain has been inoperative for some time.

Walk and Talk

On September 18 a small group of Associates met at Gates Hall for the first of the autumn guided tours. The timing was perfect for a glimpse at the transition between seasons. A few plants were blooming, a few more were beginning to show color in the fruit and the first foliar coloring had begun.

Storm Damage

The Arboretum lost several large trees when hurricane Doria's wind and water hit. Several of them were along the creek below the Magnolia Slope where flooding never has been unusual. One, a gigantic oak by the garage, crashed across the parking lot. This was not unexpected because it had long been recognized that the heart-wood was in an advanced stage of decay by the fungus *Polyporus frondosus.* The real disaster came a week or so later when a third of the magnificent Buckeye, *Aesculus glabra*, came crashing down by Gates Hall. (Page 68)

ORCHIDS — WILD

David A. Caccia

Fig. 1. Whorled Pogonia, above, Pink Lady's Slipper (*Cypripedium acaule*), below. Both are New Jersey natives.

In my plant room, a small stem is pushing its fist of buds up above a clump of tapey leaves. Soon it will present a cluster of delicate blossoms, as it has done every spring since I found it in the Everglades in 1951. It is the little butterfly orchid, *Epidendrum tampense*, and was my first "wild" orchid find. Its willingness to grow on my window sill encouraged me to try growing other orchids. Before long, there were many. Some thrived and some didn't. Occasionally one would even bloom. But it was not only the blossoms that I enjoyed. The plants themselves were interesting, and as I became acquainted with a wider variety of orchids, the diversity of plant form became more intriguing.

Perhaps the most notable part of the orchid plant, after the blossom, is the pseudobulb. Most of the tropical epiphytic orchids have a modified stem called a pseudobulb that stores food and water for the plant. These take a wide variety of forms—from the cane-like stems of *Dendrobiums* to the cigar-like pseudobulbs of *Cattleyas* to the thick, disc-like pseudobulbs of the *Oncidiums*. Each season, plump new pseudobulbs are added and the older ones gradually dry. An old plant accumulates quite a cluster of shriveled back-bulbs.

From 300-foot-long vines to moss-like miniatures, orchids come in all sizes. In a Caribbean rain forest, I once collected what I thought was a moss—a many-stemmed plant no more than two inches high. A few months later, when happily growing in a terrarium, this "moss" produced a tiny flower. It had the typical orchid form of three sepals, two petals and a trumpet-like lip. It's not every day you bring home an orchid plant without knowing it!

For all the variety, there are similar characteristics that make orchids recognizable (*Morris Arboretum Bulletin* 20:19-23). Of course, it is the structure of the blossom that identifies the orchids, but even the plants themselves are usually recognizable—especially the epiphytes. Their structure is highly adapted to the habitat and conditions under which they evolved. In the dense vegetation of the rain forest, the primary struggle is for light. A small plant living on the forest floor receives little light but orchids are able to survive in the tree tops. Without roots in the soil, there is the problem of keeping sufficient water to tide over

AND WROUGHT

the dry spells. This is accomplished by storage in the pseudobulbs and fleshy leaves. Thick spongy roots quickly absorb passing rain. Depending on the length of the dry season, the plants have varying water-holding capacities.

As orchids moved from the rain forest, where they probably originated, they adapted to a wide variety of conditions. There is a little *Oncidium* I saw growing in an arid region attached to a cactus. This really shattered the image of orchids in a steaming jungle!

Then there are the many terrestrial orchids of the temperate zone. These grow in scattered locations throughout the U.S. New Jersey alone has about twenty species. The main interest in these is the blossom, as the plants are usually quite simple—often with only a few grass-like leaves.

As a sculptor, I have a special interest in the endless forms of nature. With a room full of orchid plants, it was only a matter of time before I used them as subjects. My first attempts were very generalized. But the more I worked with them, the more I tried to make specific plants. This means not only getting the biological details reasonably accurate, but even more important, capturing the stance or posture of the plant. The curve of a stem is at least as important as the number of sepals.

Since I use stainless steel, I am forced to take many liberties with the biological details. But I feel that this material is well suited for expressing the aesthetic essentials of the plant.

Whatever my subject, I always try to work from nature or live models. If I want to make one of our little native orchids, I will study and sketch them in the woods—after first finding them, which is not always easy. Working from my sketches, I lay out the parts and cut them out from stainless steel sheet stock. The most time-consuming operation is then hammering each part to shape. The technique is not unlike silversmithing, using an assortment of hammers and anvils. The parts are then soldered together using several alloys of silver.

Finally, there is the problem of a base to mount the plant on. I have used many materials including marble, natural stone, plastic and wood, but my preference is for wood when it is free to show its inner character.

Fig. 2. *Oncidium splendidum*, above, Yellow Lady's Slipper (*Cypripedium calceolus*), below. The *Oncidium* is a native of Guatemala.

Fig. 1. The great oak fallen. P. Allison photo.

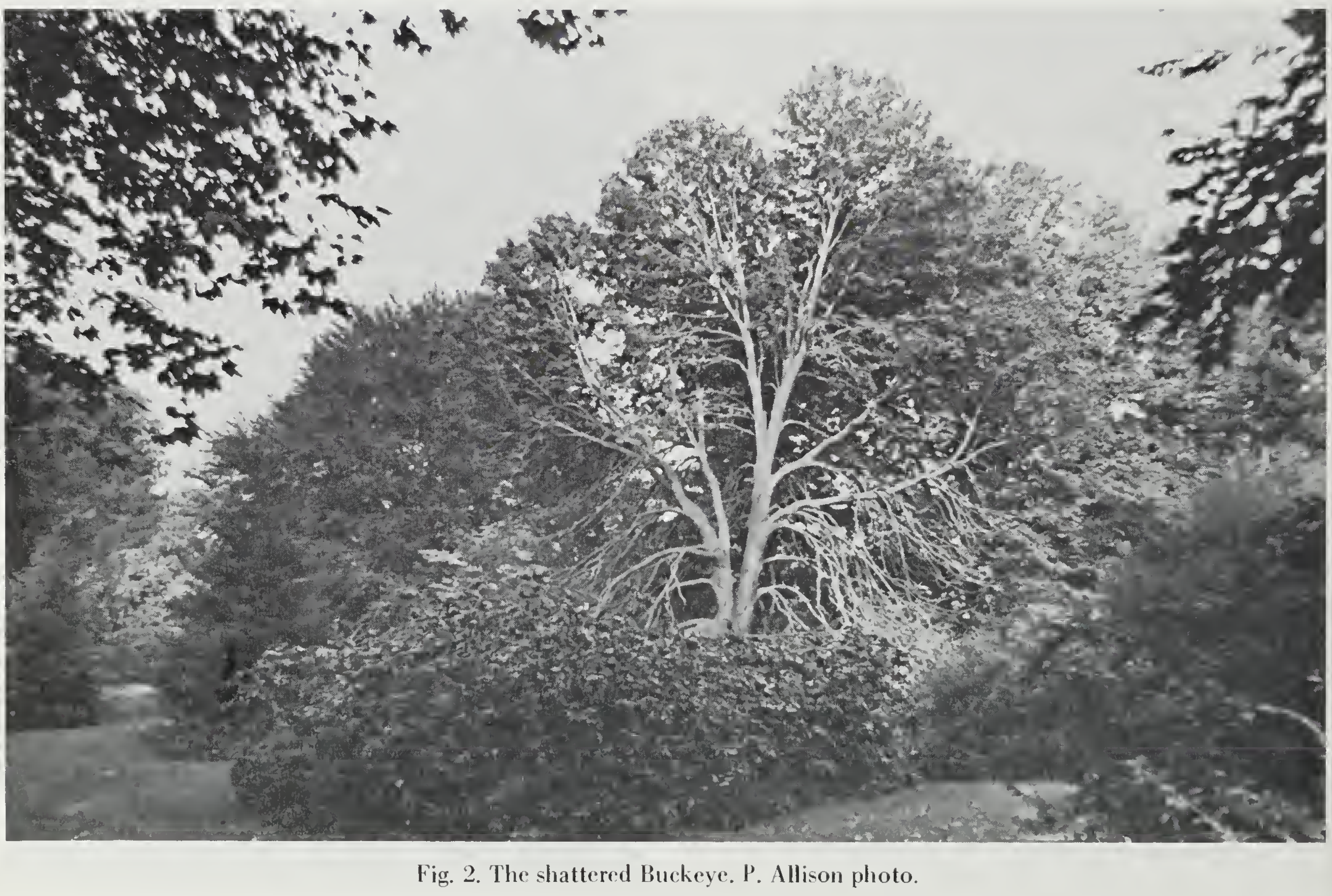

Fig. 2. The shattered Buckeye. P. Allison photo.

UNIVERSITY OF PENNSYLVANIA
THE MORRIS ARBORETUM

OPERATING STATEMENTS

for the period 1 July 1970-30 June 1971

MORRIS FUND[1]

INCOME:	
Funds received from Morris Trust	$131,600.00
Other (Building maintenance fees)	1,296.89
Total income	$132,896.89
EXPENSES:	
Salaries and Wages:[2]	
Academic	$ 43,070.38
Supervisory and Administrative	21,102.78
Grounds Maintenance	61,839.44
Sub-total—Salaries and Wages	$126,012.60
OPERATING EXPENSES:	
Fuel, water and utilities	$ 8,295.94
Maintenance—All	2,213.85
Rental Fees (Equipment)	702.21
Security Service	1,929.60
Stationery, office supplies and postage	744.51
Supplies and other miscellaneous expense	4,114.16
Travel Expense	1,125.10
Sub-total—Operating Expenses	$ 19,225.37
EQUIPMENT (Purchased)	$ 3,631.65
TOTAL EXPENSES	$148,869.62
OPERATING DEFICIT (1970-71)	$(15,972.73)[3]

[1] First Penna. Bank & Trust Co. are the trustees for the Morris Arboretum Fund.

[2] Includes employee benefits on all salaries.

[3] Deficit charged to small Reserve fund which is held by the University of Pennsylvania.

NON-CHEMICAL CONTROL OF PLANT PARASITIC NEMATODES

P. M. Miller

Plant Pathologist, Connecticut Agricultural Experiment Station, New Haven, Connecticut

Persons recently aroused to the problems of environmental protection frequently assume that entomologists, nematologists, and phytopathologists have been interested only in chemical means for the control of plant pests. Such an assumption is not only false but harmful. Generations of plant scientists have worked to reduce losses by many means other than by the use of toxicants. Many of the techniques that were developed after years of research on plant and pest alike, have become so widely accepted and practiced as to become invisible to the eye of the novice "ecologist" or even the skillful home gardener. Crop rotation and the development of resistant varieties are outstanding examples. As a public service, we here present a close-up review of one aspect of the plant pest problem: the control of pathogenic nematodes by non-chemical means. A glance at the bibliography will reveal unequivocally that such research has been going on for decades.

Each year plant parasitic nematodes cause millions of dollars of damage to food crops, ornamental plants, and trees. Many of the crops injured by nematodes do not have sufficient value per acre to pay for control by nematicides. Also, nematicides are difficult to use in small yards and gardens. However, there are other methods which can help reduce nematode damage without the use of nematicides. These methods may be physical destruction of the nematodes, different methods of biological control, use of resistant varieties, and crop rotation.

Heat can be used to control nematodes in or on plants. The thermal death point or amount of heat necessary to kill nematodes varies with the species and with the different stages of the same nematode. Likewise, the temperature that plants may withstand varies with the plant, stage of dormancy and other factors.

Hot water treatment of infested plant tissues has been used with success on plants with bulbs, fleshy roots and fibrous roots. Fibrous rooted plants, however, are less tolerant of high temperatures than the plants with large roots, bulbs or large storage organs. Dormant plants are more resistant to hot water treatment than non-dormant plants. There is very little difference between temperatures needed to kill nematodes and temperatures which can kill or injure plants. Therefore, close control of the water temperature is necessary. Accurate thermometers, thermostatic control of hot water baths, and constant agitation of the water are needed for effective treatment and prevention of injury to the plants.

The temperature required and duration of the treatment vary with the plant and nematodes. Higher temperatures require shorter periods of treatment. Dormant chrysanthemum plants are placed in a water bath for 30 minutes at 110°F to kill the foliar nematode *Aphelenchoides ritzemabosi.* Three hours in a water-formalin bath are needed to rid iris rhizomes of *Ditylenchus destructor.* The timing begins after the temperature of the bath is stabilized. Treatment of bare rooted orange trees for 10 minutes at 116°F killed both nematodes and *Phytophthora citrophthora* which causes brown rot gummosis (Baines *et al.*, 1949).

Results of hot water treatment for control of rootknot nematodes have varied. Treatment times from 30 minutes to one hour at 116°F or 120°F are required for fleshy plant organs, such as bulbs, corms, rhizomes and fleshy roots. Rootknot nematodes have been killed in dormant peony roots by treatment for 30 minutes at 120°F. Likewise, sweet potato roots were rid of rootknot nematodes by treatment for 65 minutes at 116°F (Birch and Tennyson, 1941). Treatment for 10 minutes at 122°F has killed rootknot nematodes in some plants with fibrous roots (Birchfield and van Pelt, 1958).

Hot water treatment of strawberry roots for three minutes at 127°F killed the northern rootknot nematode *Meloidogyne hapla* and the lesion nematode *Pratylenchus penetrans* with little injury to fully dormant plants (Goheen and McGrew, 1954). The plants were surface-dried and returned to cold storage. When planted one month later, survival of mother plants and runner plant production were equal in treated and untreated plants showing no injury to plants by the treatment. Runner plants planted immediately after treatment were slightly injured. Thus a waiting period after treatment may be necessary with some plants.

A pre-treatment soak and use of a wetting agent may increase effectiveness of hot water treatment. If the nematodes are in a dormant state, a pretreatment soaking for two to four hours will stir the nematodes

into activity and make them easier to kill. Addition of a wetting agent to the water will make for better kill of the nematodes. Both these procedures are used in controlling stem nematodes in narcissus bulbs. The procedure for hot water treatment of narcissus bulbs for control of stem nematodes is as follows: First the bulbs are soaked at 75°F for two hours in water containing the wetting agent Triton X-100 (¼ pint to 100 gallons of water). Then the bulbs are removed to a treating bath containing 1 pint of commercial formalin U.S.P. to 25 gallons of water. The formaldehyde helps to kill the nematodes and aids in control of some diseases. After removal from the treating bath, bulbs are dried or planted immediately. The treatment is for four hours at 110°F. (Christie, 1960).

Banana "sets" or transplants were freed of the burrowing nematode by treatment at 131°F for 20 minutes (Blake, 1961).

Grape cuttings were freed of *M. incognita* and *M. javanica javanica* by treatment for 30 minutes at 118°F, 10 minutes at 120°F, five minutes at 125°F or three minutes at 127°F. No injury occurred on cuttings of 16 varieties and four experimental strains (Lear and Lider, 1959).

Other physical methods have been tried but for several reasons were found to be unsatisfactory. Feder (1960) found that osmotic destruction of plant parasitic nematodes was obtained by addition of sugar to soil at a rate equivalent to 10 to 50 tons of sugar per acre. However, with this rate of sugar the osmotic pressure of the soil solution is high enough to cause permanent wilting of the plant. Thus, using sugar to control nematodes around living plants would cause wilting and perhaps death of the plant.

High voltage electric soil treatments have also been found impractical (Lear and Jacob, 1955).

Cyst nematodes (*Heterodera* sp.) were more resistant than other nematodes to ultrasonic treatments (Kampfe, 1962). Ultrasonic treatments are not practical at present.

Irradiation has also been tried to control nematodes. A very high dose of X-ray treatments, 360,000 roentgens, was needed to reduce by 85% emergence of larvae of *Heterodera rostochiensis* (Fassuliotis, 1955). Ionizing irradiation was tried and was also found impractical because of the length of time needed to treat even small areas (Myers and Dropkin, 1959). Plant roots are injured by amounts of irradiation less than those required to disrupt the nematode life cycle.

Flooding to control rootknot nematodes has been used successfully in Florida and California but the length of submersion necessary to kill larvae and eggs varies a great deal. In Florida one test indicated three months were necessary (Frandson, 1916). In California four months' submergence was necessary to kill larvae and 12 months or more were needed to kill the eggs (Brown, 1933). Thus, eggs are more resistant to flooding than larvae. More investigation is needed to know the length of time of submergence required,

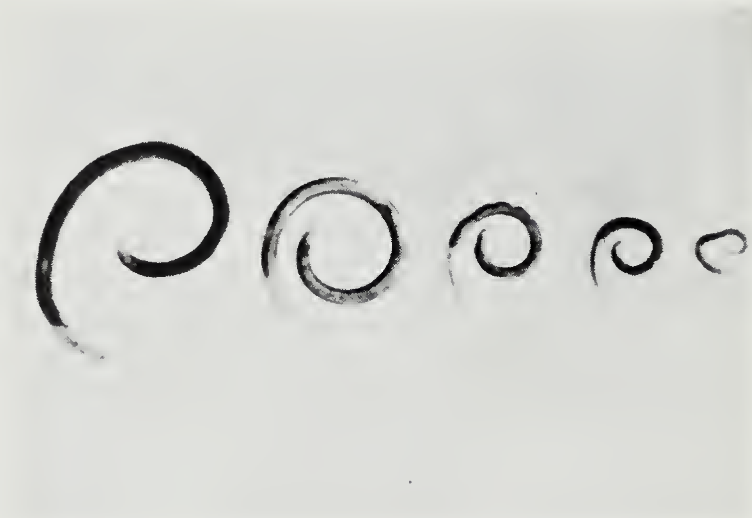

Fig. 1. Young and mature stages of a Spiral Nematode.

Fig. 2. Meadow Nematodes (***Pratylenchus penetrans***) and eggs inside an apple root.

Fig. 3. Nematodes attached to and feeding on a plant root.

(Continued on Page 78)

WINTER SCENERY AT THE MORRIS ARBORETUM

H. L. Li

Fig. 1. The grotesque scaffolding of the Arboretum's magnificent Weeping Beech, *Fagus sylvatica pendula,* is revealed during winter. On the left is *Chamaecyparis pisifera;* to the right, *Tsuga canadensis.* William Wright photo.

During the winter months, in this climate, most of the trees and shrubs shed their leaves and very few of them, if any, ever come into flower. However, at the Morris Arboretum, the scenery is far from being desolate. The Arboretum is richly endowed with conifers; nearly all of these are evergreens. Their usually fine, dense, and dark green foliage stands out more prominently at this time than at any other season of the year. Among the broad-leaved trees and shrubs a few also retain their leaves during the winter, such as the hollies and rhododendrons. Even among the deciduous trees, while they are bare of foliage, winter becomes the best time of the year to observe or study features not readily notable during the other seasons. The profiles of the trees as outlined by their bare twigs against the sky, more vividly reveal their growth forms and branching habit than do their full-foliaged shapes. Many trees have interesting and even beautiful barks that can be seen more readily at this time. Those trees that bear colorful tenacious fruits are also more noticeable in the winter than with their leaves on earlier in the year.

In addition to these features mentioned above, winter scenery has its magical charm when snow falls on the tops of the trees and over the lawn. Here at the Morris Arboretum, the varied topography and the many scenic embellishments—ponds, creeks, rock works, pavilions, lookouts and other architectural decorations, as well as the plants themselves, combine to render the snowscapes distinctively variable and picturesque. Locations of some of our winter beauties are indicated with capital letters on the map. (Fig. 2.)

Winter Flowers

The few winter-flowering shrubs all originated in eastern Asia. A truly winter-flowering one is the Wintersweet, *Chimonanthus praecox,* a Chinese plant which is perfectly hardy in Philadelphia. The waxy yellow, intensely fragrant flowers open in the winter months, usually in January and February. The Japanese Witch-hazel, *Hamamelis japonica,* and the Chinese Witch-hazel, *H. mollis,* both with yellow flowers, bloom from January to March. Two Chinese bush-honeysuckles, *Lonicera fragrantissima* and *L. standishii,* form fragrant purplish or white flowers in late winter or early spring. (A)

Winter Berries

As described in the September issue of this *Bulletin*, many trees and shrubs bear colorful berries in autumn. Some of these are long-lasting, hanging on the plants late into the winter. Besides furnishing a source of food for birds that winter in the area, they also brighten up the whitened scenery.

The most outstanding deciduous plants with ornamental fruits in the winter include the crab-apples (B), beauty-berries (*Callicarpa*) (C), bush-honeysuckles, bittersweet (D), and snowberries (*Symphoricarpos*) (E). In the hollies, viburnums and barberries, there are both deciduous and evergreen species with colorful fruits. *Pyracantha* is an important genus of evergreen plants, the firethorns, that retain their showy berries.(F)

Colorful Barks

An important feature of the trees, both botanically and artistically, is the nature of their barks. There is a wide variation in the make up of bark among the different trees. These characters are often of diagnostic value in the identification of families, genera or species. Some are quite colorful and of interesting design. These features are less obvious when the trees are shaded by the crown in full foliage.

The birches are probably the most spectacular. The bark usually peels off in horizontal strips. They vary in texture and color from the exfoliating chalky white of paper birch (*Betula papyrifera*) to the close dark reddish brown of the cherry birch (*B. lenta*). There is a stand of birch trees on the northeast side of the Swan Pond (G).

Other notable barks include the mottled white patches on the trunk and main branches of the Lacebark pine (*Pinus bungeana*) (H) and the plane trees. The beech has smooth tight light green-gray bark. A distinctively characteristic bark is found on the persimmon (*Diospyros virginiana*). The dark thick bark is prominently and deeply broken into symmetrical square scaly blocks. Two large specimens are located on the south slope, just above the Heath Garden (I).

There is a collection of small trees with interesting bark near the Hillcrest Gate along the lower driveway leading to the Drug Plant Garden (J). Beside Lacebark Pine, there are the Chinese Quince (*Chaenomeles sinensis*), Paper Bark Maple (*Acer griseum*), Striped Maple (*Acer pennsylvanicum*), Japanese Clethra (*Clethra barbinervis*), three species of *Stewartia*, and others, all with interesting and colorful barks. Besides bark, the growth form of trees is best revealed by their winter conditions. The system of branching will determine the shape of the crown. Each species generally assumes a definite pattern. The bark, growth form, as well as other features such as buds and leaf-scars are useful diagnostic characteristics of trees. They will often enable accurate determination of families, genera, or species in the winter condition. (Fig. 1)

Broad-leaved Evergreens

While most of the conifers are evergreen, relatively few of the broad-leaved trees retain their leaves throughout the seasons in this climate. These broad-leaved evergreens are desirable plants for landscaping as they offer needed variation to supplement the dense fine-foliaged conifers in retaining green during the bleak winter. The most prominent groups are the hollies and the rhododendrons.

The holly collection at the Arboretum, comprising over 100 different species and varieties, is largely centered on the southern slope of Gates Hall (K). There are tall tree forms as well as low shrubby ones. A few of them are deciduous. They bear mostly red berries, but some are with yellow, white, or black fruits.

The "rhododendrons" are the evergreen group of the genus *Rhododendron*, the deciduous species being generally referred to as "azaleas." Numerous species and varieties of rhododendrons are in cultivation at the Arboretum, the main collection being in beds spreading inside the fence along Germantown Avenue (L).

Evergreen plants in the same Heath Family include many other ornamental shrubs such as Mountain-

Fig. 2. Map of the main part of the Arboretum showing locations of important winter displays. See text for explanation of letterings.

laurel (*Kalmia latifolia*), Sheep-laurel (*K. angustifolia*), *Pieris japonica*, and *P. floribunda*. Many varieties of heaths and heathers are not only "evergreen," but vividly colored as well (I).

Other evergreen species can be found among the barberries (*Berberis*) and Oregon grapes (*Mahonia*). Most of the viburnums are deciduous, but a distinctive species, the Leather-leaf Viburnum, is not (M). The Bull Bay (*Magnolia grandiflora*) is a highly ornamental evergreen tree that is barely hardy in this climate. Our largest specimen is near the garage (N).

Among the vines, the ivies are outstanding in their evergreen habit. A collection of varieties is found along the Oak Row (O).

Evergreen Conifers

Besides furnishing us with Christmas trees, the conifers are the mainstay in giving us living green in the northern temperate world. The Morris Arboretum is fortunate in having an extensive and representative collection of fully grown specimens of the species hardy in this climate (Fig. 4). These plants are mainly located in an extended area from inside the Hillcrest Gate all the way over to the Meadowbrook Gate. There are scattered specimens in other areas as well. The genera of evergreen conifers represented at the Arboretum are as follows:

Abies	Firs
Biota	Oriental Arbor Vitae
Calocedrus	Incense Cedar
Cedrus	Cedar
Cephalotaxus	Plum-yew
Chamaecyparis	Cypress
Cryptomeria	Cryptomeria
Cunninghamia	Chinese Fir
Juniperus	Junipers
Picea	Spruce
Pinus	Pine
Pseudotsuga	Douglas Fir
Sciadopitys	Umbrella Pine
Sequoiadendron	Big Tree
Taxus	Yew
Thuja	Arbor Vitae
Torreya	Torreya
Tsuga	Hemlock

Among these are some of the monotypic, rare genera. *Sequoiadendron gigantea* (Big Tree), a relative of the California Redwood, is barely hardy in this climate. A slow growing specimen is found along the path below the Studio (P). The Umbrella tree (*Sciadopitys verticillata*) from Japan is another slow-growing plant with unique large needles. There is a fine, tall specimen in the Japanese Garden (Q). *Cunninghamia lanceolata*, native to China, is a striking plant with long broad sharply-pointed bright green needles. A large specimen is located along the walk inside the Hillcrest Gate (R). A number of *Cryptomeria* specimens, native to eastern Asia, are scattered around the grounds. *Biota orientalis* is an eastern Asiatic species (S) included sometimes in the genus *Thuja*, which contains the common native Arbor Vitae, *T. occidentalis.*

Among the true cedars, the largest specimen of the Cedar of Lebanon (*Cedrus libani*) stands inside the azalea bed along Hillcrest Avenue. Several beautiful specimens of the Atlas Cedar (*C. atlantica*) (Fig. 3) are found on the west side of the Azalea Meadow (T). The longer needled and more tender Deodar (*C. deodara*) is represented by a specimen in front of the Garage (N).

Besides the more familiar species of yews (*Taxus*), the Arboretum has a mature specimen of the rare

Fig. 3. (Preceding pages.) Winter surprise. Pots of young deciduous viburnums capped with snow in the lath house. William Wright photo.

Fig. 4. The grandeur of the Atlas Cedar, *Cedrus atlantica*, is enhanced by the winter snow. William Wright photo.

Chinese yew (*T. chinensis*) by the side of the Temple of Mercury (U). A related genus, *Cephalotaxus*, from eastern Asia, bears similar but longer, more graceful foliage. Another related genus, *Torreya*, is represented by a full-grown specimen of the Japanese *T. nucifera*.

Juniperus (junipers) as well as *Chamaecyparis* are represented by many species and varieties. In the latter genus, the Japanese species Hinoki Cypress (*C. obtusa*) and Sawara Cypress (*C. pisifera*), with many horticultural forms, are doing exceptionally well in this area. The Arboretum contains some very well developed and beautiful specimens of these species.

Among the many species of pines, the more ornamental are the Himalayan Pine (*P. wallichiana*) with its long graceful foliage, the Lace-bark Pine (*P. bungeana*) with its white chalky bark, and the Japanese White Pine (*P. parviflora*) with its reddish bark and picturesque form. They are all represented by full-grown specimens. Especially noteworthy is the Longleaf Pine, (*P. palustris*) a southern United States species which is generally regarded as non-hardy in this climate. A large specimen is located by the Heath Garden near the Baxter Memorial (V). The spruce (*Picea*) and fir (*Abies*) genera are also well represented by many species. In the case of the spruces, the European and western American species are in general doing better than their Asiatic counterparts in this area, such as the Norway Spruce (*P. abies*), White Spruce (*P. glauca*) and Blue Spruce (*P. pungens*) that grow well in this climate. In the firs, some of the species from Asia and Europe do not prove to be satisfactory with us. Others, such as the Japanese Nikko Fir (*A. homolepis*) and the Chinese Farges Fir (*A. fargesii*), do well in the eastern States and have developed beautiful specimens at the Arboretum. Similarly, some western North American species, such as Colorado Fir (*A. concolor*) and Noble Fir (*A. nobilis*), thrive well in this climate and produce well shaped specimens with us. Many good specimens are located along Hillcrest Avenue (W).

The conifers are known for their ability in developing into many horticultural shapes under cultivation, such as prostrate, drooping, dwarf, or fastigiate forms. Many of these variations are represented at the Arboretum with mature specimens. The dwarf forms of conifers have in recent years become especially popular in landscaping. A collection of these dwarf conifers is located along the southern edge of the greenhouse compound along the drive (X).

(Continued from Page 71)

variation of this time during the year and also the resistance of the eggs to flooding.

Rootknot nematodes can also be controlled by keeping the soil fallow and weedfree for several months. Since rootknot nematodes must feed on live roots to survive, keeping the soil free of plants deprives them of feeding places.

Many nematodes are susceptible to drying. This susceptibility to drying has been used in Texas to control rootknot nematodes. The field is plowed so that diseased roots are brought to the soil surface where the egg masses are killed by drying winds and sunlight. Two more cultivations at six- to eight-week intervals were needed to expose all roots in the soil (Godfrey, 1947).

Fig. 4. Nematode damage to potatoes. The plants in the foreground are stunted from root injury by the Meadow Nematode.

Biological Methods of Nematode Control

The biological control of parasitic nematodes is aided by predatory nematodes, predatory fungi, other predatory soil fauna, and addition of organic matter to soil.

Predatory nematodes help control plant parasitic nematodes. There are three types of predatory nematodes (Christie, 1959). One group has a smooth esophagus and swallows prey whole. Some of these predatory nematodes can swallow prey half as wide as they are.

In the second type, the lip or opening of the esophagus has one or more large puncturing teeth or small grasping teeth or both. Predators of this group slash or puncture the body wall and suck out the inner parts of the nematode. They also can swallow some prey whole. *Mononchus papillatus* is a voracious feeder and feeds on many different nematodes. *Mononchus* has been found feeding on mature males and larvae of *H. schachtii* in cysts opened by artificial means (Thorne, 1927).

Predators of the third type have a stylet which they use to puncture the body walls of prey. Several species of *Aphelenchoides* are predators. Linford, Yap and Oliviera (1938) found that *Aphelenchoides* injected saliva into other nematodes and the host became paralyzed. They found that *Dorylaimus* types of predators were more effective than the *Mononchus* type. Many species in the family *Dorylaimidae* belong to this group of predators including *Discolaimus, Discolamium* and *Dorylaimus. Dorylaimus* sp. was found inside *Heterodera* cysts and often a small hole was found in the cyst wall. The *Dorylaimus* appeared to be feeding on the eggs inside the cysts.

Fungi as well as animals prey upon nematodes. These fungi also grow as saprophytes in compost heaps and dung piles. Most of these belong to the genera *Tricothecium, Arthrobotrys, Dactylaria,* and *Dactylella* (Supronov and Galimliva, 1951).

Two types of traps, sticky and mechanical, are used by fungi that catch nematodes. The adhesive network is the most common type of sticky trap. *Arthrobotrys oligospora* forms a network of sticky loops. Nematodes touching their surface are held fast; then mycelium enters the nematode and digests internal tissues. Another type of sticky trap is formed by *Dactylella lobata* and *D. enonophagus.* These traps have short lateral branches forming on a stalk. They are coated with an adhesive to catch the nematode. A third type uses spherical adhesive knobs to catch nematodes.

Fig. 5. Young traps of the nematode-trapping fungus *Arthrobotrys conoides.* Donald W. Iffland photo.

Mechanical traps are of two types, non-constricting rings and constricting rings. In the non-constricting trap, a branch from the mycelium forms a loop of three cells. As nematodes go through the loop, they get caught and are held tight by the loop. Hyphae then enter the nematode to feed.

The constricting ring is also made of three cells. These three cells are sensitive to touch. A nematode entering the ring contacts the ring cells; these cells suddenly inflate to three times their former volume. The inflation is mainly toward the center. The nematode is then held tightly by the tightened loop around its body. The tightening of the loop may take only 1/10 of a second.

Supronov and Galimliva (1957) reduced rootknot nematode injury by growing predatory fungi for several weeks in the lab and then mixing the fungi with soil infested with rootknot nematodes. The number of galls per plant was reduced from 23 to 0.6 when the fungi were added.

Predatory fungi were most effective when there were high populations of nematode larvae and least effective in wet soil (Supronov and Galimliva, 1951). Addition of ammonium carbonate to the soil may help predatory fungi (Supronov and Galimliva, 1957). Gorlenko (1956) added predaceous fungi to rootknot nematode infested soil, and control became better with each increase in amount of fungus. Frequent additions of fungi worked better than one single large addition. Another fungus *Didymozoophaga* sp. was predatory in alkaline soil but not in acid soils. In another test with several nematode-trapping fungi in greenhouse and field plots, *Dactylella ellipsospora* and *Arthrobotrys oligospora* were the most commonly recovered fungi. Soil treated with *D. ellipsospora* had plants with less root damage than soil infested with other fungi (Linford and Yap, 1939).

Predaceous fungi are often difficult to establish in soil. Attempts to control rootknot damage to tomatoes and okra by addition of *Dactylaria thaumasis* and *Arthrobotrys arthrobotryoides* to soil containing *M. hapla* were unsuccessful (Mankau, 1961). Other attempts to establish predaceous fungi in soil have failed. Part of this failure is apparently due to antagonisms by other soil microorganisms. In laboratory tests, several species of predaceous fungi were inhibited by several species of *Penicillium*, *Aspergillus terreus*, and two isolates of *Bacillus*.

In a greenhouse test, three nematode-trapping fungi made tomatoes grow bigger but did not prevent serious damage to the roots (Mankau, 1961).

Only one of five different fungi tested gave any control of rootknot on pineapple (Linford and Yap, 1939). Predaceous fungi are ineffective against rootknot infestation on such favorable hosts as tomato and okra (Mankau, 1961b).

Soil microfauna also aid in nematode control. The Collembola, *Onychiurus armatus*, was the most voracious predator found on *Heterodera cruciferae* (Murphy and Doncaster, 1957). *O. armatus* has been found to feed on *Dorylaimus*, *Mononchus*, white females of *H. cruciferae* and adults and fourth stage larvae of *H. schachtii* var. *trifolii* (Murphy and Doncaster, 1957). In one test several *O. armatus* were placed in a container with four young white females and one fourth stage larva of *H. schachtii* var. *trifolii.* One female was partially digested, another was eaten completely. Body contents were removed from two and the remaining female was untouched. Once females turned brown, they were not attacked. In another test 7% to 25% of cysts were found damaged by *O. armatus.* When four Collembola were combined with a new cyst of *H. cruciferae*, a juvenile *Hypogastura* was seen feeding on this cyst. The Collembola *Orchesella villosi* was used in a separate test and ate away part of the cuticle of the cyst (Murphy and Doncaster, 1957). According to Murphy and Doncaster (1957) Hesling has seen soil mites, sub-order *Mesostigma*, feeding on egg sacs of *H. schachtii.*

Biological control aims at increasing parasites and predators of nematodes. This can be done only by changing the soil environment, such as by the addition of organic amendments or by putting other organisms into the soil. However the soil acts like a large buffer, and the establishment of organisms placed into the soil will be determined by the organisms already in the soil, and also the ecology of the soil itself. Thus to think that the mere addition of predators to soils will increase their levels is not realistic.

In order to increase the natural controls of nematodes by fungi in the soil, it will be necessary to change the environment to favor reproduction of these organisms. Usually a soil amendment was used to favor the trapping fungi but many of these experiments failed to control the nematodes (Duddington, Jones and Moriarity, 1956; Duddington, Jones and Williams, 1956). *Dactylaria thaumasii* and *A. arthrobotryoides* did not control *M. incognita* even with soil amendments (Mankau, 1960, 1961). Also, it is difficult if not impossible to give quick protection to crops highly susceptible to rootknot nematodes by use of predaceous fungi.

Aiding Nematode Control by Use of Organic Matter

Several workers have found that addition of organic matter to soil has reduced nematode populations. Sometimes a mixture of organic matter plus predaceous fungi was used. Addition of chopped

pineapple tops into soil reduced rootknot nematode injury (Linford, Yap and Oliviera, 1938). Cabbage worked into the soil reduced the soil content of larvae of *Heterodera avenae* (Duddington and Duthoit, 1960). A combination of green manure plus the predaceous fungus *Dactylaria thaumasii* reduced damage by *H. avenae* to oat seedlings.

Some organic amendments favor nematode-trapping fungi more than others. Steer dung and alfalfa (green manure) applied to soil resulted in the richest predaceous flora. *Dactylaria brochopaga* was the most effective of the fungi recovered (Mankau, 1962).

Linford and Yap (1939) failed to get good control of rootknot nematode in pineapples in Hawaii by adding predaceous fungi to soil. However, the addition of chopped pineapple tops resulted in a large increase in saprozoic nematodes followed by a very dramatic drop in all soil nematodes (Linford and Oliviera, 1938). Green manure gave some control when incorporated in soil in which pineapples were grown (Duddington, 1960). Application of organic matter may help control nematodes by encouraging microorganisms that inhibit nematodes or by improving fertility so that the plant grows in spite of the presence of rootknot nematodes (Smith and Battista, 1942). In Florida, mulches of decaying organic matter improved growth of plants and reduced damage by rootknot nematodes (Watson, 1944). Addition to the soil of 11 types of finely chopped crop residues at rates of five and ten tons per acre reduced injury by rootknot nematodes (Johnson, 1959). Thirty weeks after addition of lespedeza hay to the infested soil, rootknot injury was reduced 95%. In another test, easily decomposible amendments increased *microphagous* nematodes. The populations of the predaceous nematode Dorylaimus were also increased. Dung and alfalfa (green manure) appeared to stimulate activity of predaceous fungi the most. Legume hay or legume hay and pine straw buried deeply under the roots increased yields in the presence of meadow and rootknot nematodes but no yields increased in the absence of parasitic nematodes (Gaines, 1945). Five to 10 tons of castor pomace were required to obtain 50% reduction in injury by *M. javanica* and *H. rostochiensis* (Lear, 1959). Sawdust and paper mixed with soil reduced damage by *Pratylenchus penetrans* (Miller and Edgington, 1962). Tobacco stems, sawdust, paper, and cottonseed meal reduced injury by *H. tabacum* (Miller, Taylor and Wihrheim, 1968). Populations of the citrus nematode, *Tylenchulus semi-penetrans*, were reduced 50% to 100% by several soil additives. Castor pomace eradicated *Rotylenchulus semi-penetrans* (Mankau and Minteer, 1962).

How organic matter aids control of nematodes is not clear. Organic matter introduced into soil increased numbers of saprophagous nematodes. Then the predaceous nematodes will feed on the very numerous saprophagous nematodes and parasitic nematodes also. Gaines (1945) suggests three ways organic matter may help to control nematodes: 1) production by microorganisms of metabolites toxic to nematodes may be stimulated by the organic matter; 2) growth of microorganisms antagonistic to nematodes may be stimulated; and 3) extra nutrients from the organic matter may stimulate plant growth in spite of the nematodes.

Fertilizer may stimulate damage by cyst nematodes as compared to manure. Van der Laan (1956) found that 22 days after planting, there were 2295 larvae in fertilized plots, 1186 larvae in manured plots, 662 larvae in the fertilizer plus manure plots, and 1027 larvae in the check plots. Meadow nematodes on several crops were fewer where manure was applied than where fertilizer was applied (van der Laan, 1956). In plants 33 days old, the number of nematodes for each treatment was as follows: fertilizer 1350 larvae; manure 956 larvae; manure plus fertilizer, 794 larvac; and check, 1036 larvae.

Using Resistant Plants to Control Nematodes

Resistance to nematodes has been obtained in many cases. Resistance to the golden nematode of potatoes, *H. rostochiensis*, has been found in four breeding lines of *Solanum tuberosum* var. *andigena*, in the diploid species *S. vernei*, and in a sterile triploid. Two varieties resistant to *H. rostochiensis* have been developed from this *S. tuberosum* variety in the United States and resistant varieties have also been developed in Europe. There are, however, in England strains of *H. rostochiensis* which will grow on potatoes with the *S. tuberosum* var. *andigena* type of resistance.

Resistance and susceptibility to nematodes varies. A plant is susceptible if nematodes mature and reproduce on the plant. A plant is resistant if no reproduction occurs. Dropkin and Nelson (1960) found four responses of soybeans to *M. incognita* and *M. incognita acrita:* 1) all cells surrounding the larvae die—hypersensitivity; 2) cells near the larvae undergo some fusion and have peculiar cellular contents; 3) cells enlarge and contain many nuclei, and the cytoplasm is diffuse with many vacuoles. These three reactions were found in resistant plants in which no reproduction of nematodes occurs. In the fourth type of reaction, giant cells are formed with thicker walls, many nuclei and dense protoplasm. Such plants permit rapid reproduction of the rootknot nematode.

Feder and Ford (1957) divided citrus trees into three classes depending upon their reaction to the burrowing nematode, *Radopholus similis*: 1) tolerant plants showing good growth in which undamaged roots contain nematodes; 2) susceptible plants in which growth is poor, roots show much damage and contain high nematode populations; and 3) resistant plants which made good growth and had a good root system with few nematodes.

Nematodes may or may not enter resistant and susceptible roots in equal numbers. Several workers have found that nematodes entered susceptible roots more than resistant roots. Sasser (1962) found some plants resistant to *Meloidogyne* spp. were invaded less frequently than susceptible plants. However, *R. similis* entered roots of resistant and susceptible citrus trees in equal numbers (Feder, and Ford, 1957), and rootknot nematodes entered roots of resistant and susceptible tomatoes in equal numbers. However, larvae died within 96 hours in the resistant tomatoes.

Resistance may sometimes be due to chemical differences among varieties of plants. Mountain and Patrick (1959) found that roots of the peach variety 'Shalil' supported large numbers of *P. penetrans* without becoming stunted, but seedlings of the variety 'Lovell' contained smaller populations and were stunted. Mountain and Patrick (1959) suggested that resistance in 'Shalil' peaches was due to a low content of amygdalin, but Wallace (1963) suggested that the low population in 'Lovell' peaches might be due to their hypersensitivity to *P. penetrans*. Wallace (1961) found that leaves of varieties resistant to the foliar nematode turned brown very quickly. This stopped reproduction and spread of the nematodes. Leaves of susceptible varieties browned more slowly and allowed reproduction and spread of the nematode. Red clover has varieties resistant to the stem and bulb nematode. The variety 'Marker' is resistant to all biotypes of the nematode found in Sweden.

A variety resistant to one nematode may be susceptible to other nematodes. Graham (1960) found a breeding line of tobacco resistant to the rootknot nematode, *M. incognita acrita*, but found this line was susceptible to other rootknot nematodes, *M. javanica* and *M. arenaria*. Thus resistance to as many species of nematodes as possible is desirable in breeding work.

Several varieties of citrus have been found that are tolerant or resistant to the burrowing nematode *R. similis* (Ford et al., 1959). Nelson (1956) found a line of corn resistant to the stunt nematode.

Resistant varieties may be resistant to certain strains of the nematode in one area and susceptible to this nematode in other areas. A tomato line, Hawaii 5529, developed as resistant to *M. incognita*, *M. incognita acrita*, *M. javanica*, and *M. arenaria* (Winstead and Barham, 1957), was found in another test to be susceptible to *M. incognita*, *M. incognita acrita* and *M. arenaria*.

Some plants are known to produce nematicidal chemicals. The roots of the asparagus variety 'Mary Washington' are resistant to *Trichodorus christiei*. When roots of this variety were interplanted with other varieties of asparagus, all were protected from nematodes. A nematicidal substance produced in roots of the resistant 'Mary Washington' variety was found in the soil, particularly in the large storage roots. The compound is a glycoside with an aglycone of low molecular weight. It is toxic to six nematodes other than *T. christiei*. It apparently interferes with the enzyme acetylcholinesterase in the nematodes.

Fig. 6. The marigold, *Tagetes patula* (foreground) is toxic to the meadow nematode. Burpee photo.

Slootweg (1956) found that *Tagetes* or marigolds reduced populations of a meadow nematode *P. penetrans*. Under appropriate conditions marigolds could be used to greatly increase production of narcissus bulbs. *Tagetes patula*, when grown as a main crop, decreased *P. penetrans* populations 90% (Oostenbrink, *et al.*, 1956, 1960). *Tylenchorhynchus dubius* was also suppressed. But *Rotylenchus robustus*, *Criconemoides* spp. and several other parasitic nematodes were not suppressed. Marigolds interplanted with apples and roses reduced nematode populations in roots of the apples and roses. Several nematicidal chemicals from marigold roots were identified as derivatives of 2,2′-bithienyl (Uhlenbroek and Bijloo, 1958, 1959, 1960).

Miller and Ahrens (1969a) found that marigolds suppressed *P. penetrans* populations for three years but suppressed populations of *Tylenchorhynchus claytoni* for only one year. The marigolds controlled *P. penetrans* as well as did fumigation with 6 gal/acre of the nematicide ethylene dibromide. Petunia, tobacco, tomato, zinnia, snapdragon, calendula, privet, and other plants grew much better in soil where marigolds had grown than in soil where rye and crabgrass had grown. This rye-crabgrass soil contained many *P. penetrans* and *T. claytoni*, but the marigold soil had very few of either nematode.

Marigolds were resistant to rootknot nematodes, *Meloidogyne* spp. (Tyler, 1941; Christie, 1959; and Daulton and Curtis, 1963). Larvae that entered marigold roots failed to develop. Oostenbrink (1960) reported that marigolds helped to control *M. hapla.* Daulton and Curtis (1963) reported that when tomatoes followed two crops of marigolds galling due to rootknot nematodes was almost eliminated. Galling was cut 50% if a crop of marigolds was planted between two crops of tomatoes. Marigolds, however, had no effect on *H. rostochiensis*, the golden nematode of potatoes (Omidvar, 1961; Hesling *et al.*, 1961).

Uses of Rotation for Nematode Control

Rotation is another way to control nematodes in crops with low value per acre. Parasitic nematodes are reduced in soils when crops that are not hosts for the nematodes are used in a crop rotation. Rotation works best when only one or two species of nematodes are to be controlled, and control will be very difficult if several species are present in the soil. Until more information exists on the hosts of ectoparasitic nematodes, which feed on roots from the outside, suitable rotations for control of these nematodes cannot be given.

The cereal crops are often suggested as alternate crops in soils infested with rootknot nematodes, but some of them can be infected at some time (Markaner, 1951; Gaines, 1945).

Crop rotation is the most widely used method to control golden nematode of potatoes. Brown (1961) showed how rotation can increase yields. In one field the yield of the second successive potato crop was 8780 kg/hectare. With a non-host the first year, the yield was 12544 kg/hectare. Therefore the number of successive potato crops is restricted in Great Britain. For example, in Northern Ireland potatoes cannot be grown more than twice in 8 years and only in fields sampled and found free of *H. rostochiensis.* Similar restrictions on crop sequences are common in Europe; but there are few restrictions found in the U.S.A., although workers have shown rotation to improve yields in this country.

In suggesting a crop rotation program, the nematodes present in the soil, their host specificity, and relationship between number of nematodes and crop damage must be known (Wallace, 1963). Some nematodes have such a wide host range that rotation is not feasible. A specific order of rotation may be valid in one local area only.

It is important to know that all alternate crops in the rotation are non-hosts. Workers, however, do not always agree on the host range for a particular nematode. Cereals are often used as an alternate crop for control of rootknot nematodes. Oats are probably the best cereal alternate crop but sometimes the roots of oats may be galled (Gaines, 1945).

When two crops are planted together, a susceptible crop will grow better in combination with a resistant crop than in combination with a susceptible crop. Burton *et al.* (1946) found that 'Kobe' lespedeza grew well when used in combination with rootknot-resistant types of Bermuda grass, but lespedeza was stunted and died when grown with susceptible varieties of Bermuda grass.

These are not isolated examples. Nematode damage is often influenced by the preceding crop. Mountain (1954) found *P. minyus* severely injured tobacco when it followed corn. Severe injury occurred when tobacco followed timothy, strawberries and tobacco. Beets in a rotation suppressed *P. penetrans* populations (Oostenbrink, 1960). Potatoes and oats build up *P. penetrans* populations. Oats and wheat increase *Rotylenchus* populations. Oats can serve as a host for *Tylenchorhynchus.* Oostenbrink *et al.* (1957) found that wheat and barley were good hosts for *Pratylenchus* and *Tylenchorhynchus* and that peas, beans, and sugar beets were poor hosts for *Pratylenchus* spp. *Pratylenchus* populations were six times more numerous in roots of barley following wheat than in barley planted after beans. Infestations of *P. leiocephalus* can be reduced by growing a non-host crop of peanuts in rotation with corn. Thus, as a control measure for nematodes, rotation may be impractical because of wide host ranges of nematodes which are infesting a particular field or farm. Rotation has to be figured out for each location because of local differences in nematode infestations. Rotation must be acceptable to farmers (Wallace, 1963).

Oostenbrink (1961) found in studies on two years of cropping that corn followed by corn had more *P. penetrans* and *Tylenchorhynchus* than potatoes followed by carrots and beets followed by beets. The tests showed corn to be a good host for *P. penetrans*

and *Tylenchorhynchus* and a poor host for *Rotylenchus*, *Meloidogyne*, and *Pratylenchus*.

Oostenbrink (1960) found that rye and potatoes caused much loss of subsequently planted young apple seedlings in nurseries infested with *P. penetrans.* The unfavorable effects of potatoes may be detectable for two subsequent seasons. In another test, roses grew much better after beets than after potatoes.

In a test on a farm with sandy soil, Oostenbrink (1956) found a higher population of *P. penetrans* after rye than after potatoes, beets, oats, or as meadow land. Oostenbrink *et al.* (1956) found in a sandy clay soil, wheat increased *Pratylenchus* the most, particularly when potatoes preceded wheat and rye. Flax depressed the populations (Oostenbrink *et al.*, 1956).

Trap cropping is a special kind of rotation. The basis of a trap crop is to plant a highly susceptible crop in the soil to attract or "trap" as many cyst nematode or rootknot nematode larvae as possible. These larvae are "trapped" because rootknot and cyst nematode larvae do not leave the roots once they enter. Then the trap crop is plowed under before the maturation of the female and the trapped larvae die with the roots. If plowed too late, however, the female will mature and lay new eggs and the usefulness of the trap crop is lost. Trap cropping used correctly cannot eradicate the nematodes but can lower the number of eggs and larvae in the soil.

Fig. 7. Petunia plants may be severely stunted by the Meadow Nematode (left). When planted in soil in which marigolds grew the improvement in petunia growth is outstanding (right).

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Erratum: The captions for figures 9 and 10, pages 53 and 54, should be reversed.